Structural Parallelism Aids Ellipsis and Anaphor Resolution
Evidence From Eye Movements to Semantic and Phonological Neighbors

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VP ellipsis and VP anaphora

- VP ellipsis (1) and VP ("do it") anaphora (2)
  1. Nobody else would take the oats down to the bin, so Bill did.
  2. Nobody else would take the oats down to the bin, so Bill did it.
- =Bill took the oats down to the bin
  - Hankamer & Sag 1976, Sag & Hankamer 1984
Similarities between VP ellipsis and VP anaphora

- Both require context in order to be interpreted
  - Sally didn’t want to take the oats down to the bin, so...
  - Bill did (VP ellipsis)
  - Bill did it (VP anaphora)
- =Bill took the oats down to the bin
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= Bill took the oats down to the bin
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Differences between VP ellipsis and VP anaphora

- VP ellipsis requires an explicit linguistic antecedent.
- VP anaphora does not (Hankamer & Sag 1976).
  - Context: Sally is pointing at the empty wheelbarrow (which had been filled with oats—remember she didn’t want to take them down to the bin?)
  - ?*Bill did (VP ellipsis)
  - Bill did it (VP anaphora)
Differences between VP ellipsis and VP anaphora

- VP ellipsis prefers structurally parallel antecedent (Hankamer & Sag 1976)
  - Parallel: active antecedent VP, active ellipsis
    - Nobody else would take the oats down to the bin, so Bill did.
  - Mismatch: passive antecedent, active ellipsis
    - *The oats had to be taken down to the bin, so Bill did.*
Differences between VP ellipsis and VP anaphora

- VP anaphora tolerates structurally mismatched antecedent (Hankamer & Sag 1976)
  - Parallel: active antecedent, active ellipsis
    - Nobody else would take the oats down to the bin, so Bill did it.
  - Mismatch: passive antecedent, active ellipsis
    - The oats had to be taken down to the bin, so Bill did it.
VP ellipsis vs VP anaphora

- **VP ellipsis:** Parallel > Mismatch
  - **Parallel**
    - Nobody else would take the oats down to the bin, so Bill did.
  - **Mismatch**
    - The oats had to be taken down to the bin, so Bill did.

- **VP anaphora:** Parallel ≥ Mismatch
  - **Parallel**
    - Nobody else would take the oats down to the bin, so Bill did it.
  - **Mismatch**
    - The oats had to be taken down to the bin, so Bill did it.

Tanenhaus & Carlson 1990
Structures

**VP ellipsis**
- The security guard opened the lock, and the night watchman did too

**VP anaphora**
- The security guard opened the lock, and the night watchman did it too

\[
\lambda x. \text{open}(x, \text{lock})
\]
Relaxed mismatch

1. This information could have been released by Gorbachov, but he chose not to. (Daniel Shorr, NPR, 10/17/92, from Hardt 1993, cited in Arregui et al. 2006)

2. In March, four fireworks manufacturers asked that the decision be reversed, and on Monday the ICC did. (From Rosenthal 1988; cited in Dalrymple et al. 1991, Kehler 2002)

3. This problem was to have been looked into, but nobody did. (From Kehler 2002, cited in Arregui et al. 2006)
Parallelism and VP ellipsis

- Sensitivity to antecedent VP structure related to discourse coherence relation between two clauses (Kehler 2002)
- Parallelism triggers (like ‘too’) increase sensitivity to antecedent VP structure (Frazier & Clifton 2006)
- The studies presented today are designed to maximize the effects of parallelism
  - Clauses related by “resemblance” relation, and involve triggers like ‘too’.
New way to test for structure in ellipsis and anaphora--1

- Nouns activate semantic related neighbors
  - Visual world: more looks to pictures of both TARGET noun and semantically RELATED item than to control distracter images (Huettig & Altmann 2005, Yee & Sedivy 2006)

1. The security guard opened the lock
   - =more looks to a picture of a lock (TARGET) and a picture of a key (RELATED) than to other control items
New way to test for structure in ellipsis and anaphora--2

- Nouns also activate phonologically related items
  - Again, in visual world: more looks to pictures of both TARGET and phonologically RELATED items than to control distracter images (Allopenna et al. 1996)
  - “log”
  - More looks to TARGET (log) and phonologically RELATED (lock) compared to distracter images
New way to test for structure in ellipsis and anaphora

- Elided VP reactivates antecedent VP
  - Cross-modal lexical priming: semantically related neighbors of antecedent of reflexive in elided VP reactivated (Shapiro, Hestvik, Lesan & Garcia 2003)
    1. The optometrist who had signed the release form asserted himself, and ...
       the pilot who needed to pass [1] the training exam did [2] too, according to someone who was there.
  - Decreased lexical decision latency to word semantically related to ‘pilot’ at position of elided VP ([2]) as compared to earlier position in string ([1])
  - Interpreted as suggesting elided VP [assert himself] present at ellipsis site.
New way to test for structure in ellipsis and anaphora

- Makes prediction about VP ellipsis and VP anaphora resolution
  - If VP structure is present at ellipsis site, then semantic or phonological neighbors of NP in elided VP should be reactivated
  - More looks to both target noun and semantic or phonological neighbor than to control images during ellipsis processing
Structures

**VP ellipsis**
- The security guard opened the lock, and the night watchman did too

**VP anaphora**
- The security guard opened the lock, and the night watchman did it too

\[ \lambda x.\text{open} (x, \text{lock}) \]
Our experiments

- Examine retrieval of antecedent word using visual world eye-tracking

Experiment 1
- Analyze looks to semantic neighbors

Experiment 2
- Analyze looks to phonological cohort
Experiment 1: semantic neighbors

- 4x1 design
- 20 participants, 24 items

The security guard opened the lock... and the night watchman did it, too (VP ellipsis)
did, too (VP anaphora)
dropped it (pronoun)
slept (intransitive)

- Yee & Sedivy (2006)
- Antecedent object is predictable given the verb
- 28 fillers, with reference to either one or two pictures
Experiment 1: semantic neighbors

- 4x1 design
- 20 participants, 24 items

*The security guard opened the lock... and the night watchman did, too* (VP ellipsis)

*did it, too* (VP anaphora)

*dropped it* (pronoun)

*slept* (intransitive)

- Yee & Sedivy (2006)
- Antecedent object is predictable given the verb
- 28 fillers, with reference to either one or two pictures
Experiment 1: semantic neighbors

- 4x1 design
- 20 participants, 24 items

The security guard opened the lock...+...
...and the night watchman

did, too (VP ellipsis)
did it, too (VP anaphora)
dropped it (pronoun)
slept (intransitive)

- Yee & Sedivy (2006)
- Antecedent object is predictable given the verb
- 28 fillers, with reference to either one or two pictures
Activation and fixations

- Assuming a linking hypothesis between “activation ... and likelihood of fixation” (Tanenhaus & Brown-Schmidt 2008)
  - Activated word triggers more fixations to a picture of that word.
  - With explicitly uttered target expressions—looks to the lock when “lock” is uttered;
  - And in looks to activated neighbors—looks to the key.
- Question: will such activation occur in cases of VP ellipsis and VP anaphora, in which case the target is not uttered explicitly.
Analysis

- Analyze looks to Target and Related (vs distractors) using mixed model linear regression
- Control for attentional state dependencies (tendency to continue fixating current region)
  - using factor represented gaze region on previous time sample (Frank et al 2008 CUNY poster, Model 3)
- Control for random effects of subject and item
First (antecedent) clause
- Replicates Huettig and Altmann (2005) and Yee and Sedivy (2006) results

- Significantly more looks to Target (lock) ($p<.001$) and Related (key) ($p<.001$)
- Predictability of object given verb accounts for early separation
First (antecedent) clause

- Replicates Huettig and Altmann (2005) and Yee and Sedivy (2006) results

- Significantly more looks to Target (lock) \((p<.001)\) and Related (key) \((p<.001)\)

- Predictability of object given verb accounts for early separation
- First (antecedent) clause
- Replicates Huettig and Altmann (2005) and Yee and Sedivy (2006) results
- Significantly more looks to Target (lock) (p<.001) and Related (key) (p<.001)
- Predictability of object given verb accounts for early separation
- Proportion of fixations to **Target (lock)** vs. distracters
- More fixations in **Ellipsis** condition (p< .001), and marginally in the **Do-it** condition (p<0.1), than intransitive control
- Target reactivated in both VP ellipsis and VP anaphora processing
- Proportion of fixations to **Related (key)** vs distracters
- More fixations in the **Ellipsis** (p < 0.05) and **Do-it** conditions (p < 0.05), than intransitive control
- Semantically related activated in both VP ellipsis and VP anaphora processing
Structures

VP ellipsis
- The security guard opened the lock, and the night watchman did too

VP anaphora
- The security guard opened the lock, and the night watchman did it too

\[ \lambda x. \text{open} (x, \text{lock}) \]
Discussion

- Evidence that referent and semantic neighbors are retrieved in both VP ellipsis and VP anaphora processing
- Consistent with the claim that VP ellipsis contains syntactic structure and VP anaphora contains semantic structure
- But can’t distinguish between the two
Syntactic vs. semantic structure

- If VP ellipsis does contain full syntactic (but ultimately unpronounced) representation then it contains the actual words
- We know target words activate phonologically related words during processing (Allopenna et al., 1996)
- Experiment 2 tests activation of phonologically related words during VP ellipsis and VP anaphora processing
- Only if syntactic structure is present in ellipsis site should phonological information be reactivated
Experiment 2: phonological neighbors

- 4x1 design
- 29 participants, 20 items

The customer dropped the lock...+
...and the manager

did, too (VP ellipsis)
did it, too (VP anaphora)
dropped it (pronoun)
slept (intransitive)

- Yee & Sedivy (2006)
- Antecedent object is not predictable given the verb
- 28 fillers, with reference to either one or two pictures
First clause proportions of fixations

As expected more fixations to both the **Target (lock)** and the phonologically **Related (log)** as compared to distracter pictures.

Reduced predictive eye movements because of unpredictability of object NP given verb
- Fixation proportions to **Target (lock)** vs. distracters
- More fixations to in **Do-it** (p<0.05) and **Pronoun** (p<0.001) conditions, and marginally in the **Ellipsis** condition (p<0.1), compared to intransitive
- Later effects, due to lack of predictability of object given verb
- Fixation proportions to phonologically Related (log) vs. distracters
- Significantly more fixations only in the **Ellipsis** condition ($p < 0.05$), in comparison to intransitive
- Phonologically related item reliably reactivated only in VP Ellipsis
Structures

VP ellipsis
- The security guard opened the lock, and the night watchman did too

VP anaphora
- The security guard opened the lock, and the night watchman did it too

λx.open (x, lock)
Discussion

- Evidence that referent and phonological neighbors are retrieved in VP ellipsis processing but not VP anaphora processing.
- Supports the claim that VP ellipsis contains syntactic structure but VP anaphora contains only semantic structure.
Conclusion

- These experiments support original Hankamer & Sag observations that VP ellipsis and VP anaphora behave differently
- Provide novel evidence that VP ellipsis involves syntactic structure while VP anaphora involves semantic structure
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