Syntactically-Conditioned Word Order Expectations & (Lack of?) Flexibility

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Comprehenders have rich knowledge about the statistics of their language:

- word frequency
- conditional word probability
- syntactic probabilities
- word order probabilities
  ...
Syntactic expectations

• How fine-grained are these expectations? (cf. Mitchell et al., 1995)

• Lexically-conditioned syntactic preferences (e.g., Desmet et al., 2006; Trueswell et al., 1994; Garnsey et al., 1997; Kamide et al., 2003)

• However, production preferences also predict more intricate patterns in the input (cf. Morgan, 2017; Bresnan et al., 2007; Lohse et al., 2004; Wasow, 2002)
Test Case: Definiteness Ordering Preference in Ditransitives
The woman wrote the author a letter.
The woman wrote a letter to the author.
The woman wrote **the author** a letter.

Argument 1
Definite

Argument 2
Indefinite

Syntactic Structure: Double Object (DO)
Definiteness Order: Definite-Indefinite
The woman wrote the author a letter.
Definiteness-Conditioned Expectations?

The woman wrote an author the letter the
Definiteness- and Syntactic-Conditioned Expectations?

The woman wrote a letter to the author.

Can we actually observe these fine-grained preferences in processing?

Are these preferences malleable to recent experience?
Outline

1. Derive predictions about incremental surprisal based on input statistics

2. Present SPR experiments that test(ed) this prediction

3. Can comprehenders adapt even for fine-grained expectations?
Corpus Study

• Corpus of syntactically annotated ditransitives (Bresnan et al, 2007)

• **Calculate surprisal** of at each sentence region for each definiteness order and syntactic structure
Estimated surprisal

Surprisal (bits)

order

definite–indefinite

indefinite–definite

Sentences:
- the/an author
- a/the letter

The graph shows the estimated surprisal for different sentence structures and word orders.

- The red line represents the definite–indefinite order, with points indicating surprisal values for sentences like 'the author' and 'an author'.
- The blue line represents the indefinite–definite order, with points indicating surprisal values for sentences like 'a letter' and 'the letter'.

The surprisal values range from 0.6 to 1.5 bits, with a noticeable decrease in surprisal as the order changes from indefinite–definite to definite–indefinite.
Estimated surprisal

DO

PO

Surprisal (bits)

order

definite–indefinite

indefinite–definite

Sentence Region

Surprisal (bits)

0.6

0.9

1.2

1.5

sent

the/an

author

a/the

letter

the/a

letter

to

an/the

author

\text{Estimated surprisal}

\text{DO}

\text{PO}

\text{order}

\text{definite–indefinite}

\text{indefinite–definite}

\text{Sentence Region}

\text{Surprisal (bits)}

0.6

0.9

1.2

1.5

sent

the/an

author

a/the

letter

the/a

letter

to

an/the

author

• Ditransitives exhibit intricate pattern

• Good environment to study fine-grained definiteness- and syntactically-conditioned expectations
Outline

1. Derive predictions about incremental surprisal based on input statistics

2. Present SPR experiments that test(ed) this prediction

3. Can comprehenders adapt even for fine-grained expectations?
Previous work

• Brown et al. (2012): interaction of structure and definiteness order

Context: A woman had just finished reading a book by her favorite author.

Definite-Indefinite, PO
The woman wrote the author a letter about how much she enjoyed his most recent book.

Indefinite-Definite, DO
The woman wrote a letter to the author about how much she enjoyed his most recent book.
... in line with fine-grained expectations

Corpus Predictions
(for verbs in Brown et al)

<table>
<thead>
<tr>
<th>Reaction Time (ms)</th>
<th>DO Structure</th>
<th>PO Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>270</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td>290</td>
<td>300</td>
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<tr>
<td></td>
<td>310</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Surprisal (bits)</th>
<th>order</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>definite</td>
</tr>
<tr>
<td></td>
<td>indefinite</td>
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<tr>
<td></td>
<td>definite</td>
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</tbody>
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<tr>
<th>Corpus Predictions (for verbs in Brown et al)</th>
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<tbody>
<tr>
<td>an/the author</td>
</tr>
<tr>
<td>the/a letter</td>
</tr>
<tr>
<td>about how ...</td>
</tr>
<tr>
<td>a/the letter to the/an author about how ...</td>
</tr>
</tbody>
</table>
Experiment 1: conceptual replication

• Self-paced reading
• **New materials** (verb repetition)
• 91 Mechanical Turk subjects
Experiment 1 Results

Residual Reading Time (ms)

Word Order
- Definite–Indefinite
  - Blue triangles
- Indefinite–Definite
  - Red triangles

DO

PO

an/the author
the/a letter
about how ...

a/the letter
to
the/an author
about how ...
Corpus Predictions
(for our materials)

Residual Reading Time (ms)

Word Order
- Definite–Indefinite
- Indefinite–Definite

Sentence Region
Surprisal (bits)

Corpus Predictions
(for our materials)

NP
PP

NP1
NP2 Realization
NP2
NP1

0.6
0.9
1.2
1.5

Sentence Region
Surprisal (bits)

order
definite
indefinite
indefinite
definite

Corpus Predictions
(for our materials)
1. Derive predictions about incremental surprisal based on input statistics

2. Present SPR experiments that test(ed) this prediction

3. Can comprehenders adapt even for fine-grained expectations?
Adaptation to changes in statistics

The experienced soldiers warned about the dangers **conducted** the midnight raid.

Fine et al. (2013)

repeated exposure $\rightarrow$ reduction in processing difficulty
Experiment 2

• Adaptation to fine-grained expectations as well?

• Exposure-test paradigm

• Same materials as in Exp 2, but only DOs

• 178 Mechanical Turk subjects
Exposure Phase

DO Definite-Indefinite Exposure (24 sentences)

or

DO Indefinite-Definite Exposure (24 sentences)

Test Phase

DO Definite-Indefinite Test (12 sentences)

+/=

DO Indefinite-Definite Test (12 sentences)

between subjects

within subjects
Exposure Phase

Corpus Predictions (for our materials)

Word Order
- Definite–Indefinite
- Indefinite–Definite

Residual Reading Time (ms)

Sentence Region

Surprisal (bits)

Order
- definite
- indefinite

Corpus Predictions (for our materials)

Exposure Phase

The woman
- wrote

an/the
- author

the/a
- letter

about

how ...

* p < 0.05
** p < 0.01
Definite-Indefinite Advantage

Indefinite-Definite Advantage

Test Phase

Exposure Order
- Definite-Indefinite
- Indefinite-Definite

an/the author  the/a letter  about how ...
Test Phase

No train x test order interaction at any region

Definite-Indefinite Advantage

Indefinite-Definite Advantage

Exposure Order
- Definite–Indefinite (a priori preferred)
- Indefinite–Definite

an/the author the/a letter about how...
Experiment 2 Summary

• Strong prior expectations for definite-indefinite order (exposure phase)

• Null effect for adaptation
  – (when data is analyzed region-by-region)
Discussion

• Comprehenders condition expectations about definiteness ordering on syntactic structure from lifetime experience

• No/little evidence that comprehenders are adaptable to new fine-grained statistics (of the type investigated here)
Future Work

• Under what conditions do we expect comprehenders to track fine-grained statistics?
  – How much evidence needed before it’s worth it to adapt?
  – Are distributions *actually likely* to vary from situation to situation?
Thank You!

HLP Lab
Christopher Langfield

KurTan Lab

Computation & Language Lab

CUNY Reviewers