Syntactic priming as a test of argument structure: A self-paced reading experiment

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GOALS

• Test two theoretical approaches to argument structure:
  – Hale & Keyser (1993, 2002) as developed in Mateu (2002),
    [AM&M]
  – Marantz (2005, 2011)

• Study their claims about the relationship between:
  – Unergative structures
  – Transitive structures
  – Small clause structures
METHODOLOGY

• Self-paced reading language comprehension study to 500 subjects over Mechanical Turk.
• Structural priming experiment within and across sentence types.
• Analyses:
  – 6 x 6 within-subjects ANOVA
  – Mixed effects Analysis of Covariance (ANCOVA)
  – Linear regression
PRELIMINARY RESULTS

• Major headline: Syntactic priming effects.
• Suggest a stronger predictive contribution of the Marantz model:
  – Significant effect of the interaction between conditions and priming in trials preceded by two trials of the same category in the Marantz model.
OVERVIEW OF THE TALK

• Two syntactic models. Review of main claims
  – H&K / AM&M
  – Marantz
• Predictions of each model
• Structural priming in comprehension. Review
• Experiment. Design and implementation
• Analyses of the data
  – ANCOVA 1.0
  – ANCOVA 2.0
  – Linear mixed effects regression model
TWO SYNTACTIC MODELS

• Two representational models of argument structure:
  – Marantz (2005, 2011)
TWO COMPETING HYPOTHESES

<table>
<thead>
<tr>
<th>VERB TYPE</th>
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• Attribute different structures to transitive structures.

• Make different claims about the relationship between transitive structures and unergatives.

• Make different predictions about priming relations between sentence types.

• Theory of the lexicon-syntax interface

• Main questions:
  – Why are there so few (syntactically relevant) thematic roles?
  – Why are there so few lexical-syntactic categories?

• Through independently established principles of syntax, they seek to constrain
  – range of argument structures
  – number of θ-roles
  – verb meanings
  – lexical categories

• θ-roles and categories are limited in number because the potential structural positions are also reduced: head, complement, specifier.

• Argument structure is “the syntactic configuration projected by a lexical item”, i.e. “the system of structural relations holding between heads (nuclei) and their arguments” (2002:1).
Essentially, Hale and Keyser's answer is that (syntactically relevant) thematic roles are limited in number because the number of specific and complement positions of the abstract syntax of lexical-syntactic structures is also quite reduced. This paucity of structural positions is related to the reduced number of l-syntactic categories of the abstract syntax of argument structure. Hale and Keyser conceive of argument structure as the syntactic configuration projected by a lexical item. Argument structure is the system of structural relations holding between heads (nuclei) and the arguments linked to them and is defined by reference to the head-complement relation and the head-specifier relation. A given head may enter into the structural combinations in (23). According to Hale and Keyser (2002), the prototypical or unmarked morphosyntactic realizations of the head (x) in English are the following ones: verb in (23a), preposition in (23b), adjective in (23c), and noun in (23d).

(23)

The main empirical domain on which their hypotheses have been tested includes unergative creation verbs such as laugh, transitive location verbs such as shelf or transitive locatum verbs such as saddle, and (anti)causative verbs such as clear. Unergative verbs are hidden transitives in the sense that they involve merging a non-relational element (typically, a noun) with a verbal head (24a); both transitive location verbs such as shelf and transitive locatum verbs such as saddle involve merging the structural combination in (23b) with the one in (23a): (24b). Core unaccusative verbs involve the structural combination in (23c). Finally, causative verbs involve two structures: (23c) is combined with (23a): (24c).

Hale and Keyser (2002) also provide arguments for distinguishing causative constructions such as (24c) from transitive ones such as (24b): only the former enter into the causative alternation owing to their having a double verbal shell (24c).

(24)
H&K: Unergatives and V of creation

- Empirical evidence: e.g. Basque

Unergatives

\[
\begin{array}{c}
V \\
V \\
[∅] \\
\sqrt{LAUGH}
\end{array}
\]

V of creation

\[
\begin{array}{c}
V \\
V \\
make \\
trouble
\end{array}
\]
Essentially, Hale and Keyser's answer is that (syntactically relevant) thematic roles are limited in number because the number of specifier and complement positions of the abstract syntax of lexical-syntactic structures is also quite reduced. This paucity of structural positions is related to the reduced number of l-syntactic categories of the abstract syntax of argument structure. Hale and Keyser conceive of argument structure as the syntactic configuration projected by a lexical item. Argument structure is the system of structural relations holding between heads (nuclei) and the arguments linked to them and is defined by reference to the head-complement relation and the head-specifier relation. A given head may enter into the structural combinations in (23). According to Hale and Keyser (2002), the prototypical or unmarked morphosyntactic realizations of the head (x) in English are the following ones: verb in (23a), preposition in (23b), adjective in (23c), and noun in (23d).

(23) x d.

a. x

b. x

c. α

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Hale and Keyser (2002) also provide arguments for distinguishing causative constructions such as (24c) from transitive ones such as (24b): only the former enter into the causative alternation owing to their having a double verbal shell (24c).

(24) V

a. [Ø] V

b. [Ø] V

c. [Ø] V

{the books/the horse} P

{SHELF/SADDLE} N
Acedo-Matellán (2010: 53-54)

- Strict configurational model of argument structure: compositional semantics directly read off the syntactic structure.
- Five basic structure configurations:
  - unergative and transitive verbs of creation and consumption
  - atelic transitive events
  - atelic unaccusative events
  - unaccusative events of change of state or location
  - transitive events of change of state or location
Acedo-Matellán (2010)

• Decomposition of P and adposition particles in syntax into PathP and PlaceP (e.g. Cinque & Rizzi 2010).

• Jackendoff’s (1973) conceptual decomposition of PPs into PATH and PLACE and functions such as TO, VIA, ON, etc.

• Talmy’s (1975) semantic concepts of Figure and Ground for arguments of P.
Acedo-Matellán (2010)

• Figure is the entity that moves with respect to a potential Ground.

• Relational functional head $p$
  – PathP introduces a transition that encodes the change (H&K’s Terminal Coincidence P).
  – PlaceP introduces a Figure/Ground configuration that establishes a location or state (H&K’s Central Coincidence P).

• Eventive head $v$
  – with specifier: causative configuration.
  – without specifier: unaccusative configuration.
• Unergative and transitive verbs of creation and consumption

(1) Sue danced.

\[ [\_vP [\_DP \text{Sue }] [\_v] \_v \_v \text{DANCE }] ]

(2) Sue did a dance.

\[ [\_vP [\_DP \text{Sue }] [\_v] \_v [\_DP \text{a dance }]] ]\]
AM&M

• Atelic transitive events

(3) Sue pushed the car.

\[ [\text{vP} [\text{DP} \text{Sue }] [\text{v'} \text{ v} [\text{PlaceP} [\text{DP} \text{the car}] [\text{Place', Place vPUSH}]]]] \]

(4) Sue lengthened the rope (for five minutes).

\[ [\text{vP} [\text{DP} \text{Sue}] [\text{v'} \text{ v} (=\text{-en}) [\text{PlaceP} [\text{DP} \text{the rope}] [\text{Place', Place vLONG}]]]] \]
• Transitive events of change of state or location

(5) The strong winds cleared the sky.

\[
[\text{vP } \text{[DP The strong winds ] } \text{[v PathP [DP the sky ] ] Path’ Path [PlaceP [DP the sky ] [Place’ Place vCLEAR ]]}]]
\]

(6) Sue shelved the books.

\[
[\text{vP } \text{[DP Sue ] } \text{[v PathP [DP the books ] ] Path’ Path [PlaceP [DP the books ] [Place’ Place vSHELF ]]}]]
\]
• Roots cannot be merged as complements, but are always merged as events modifiers.
  – Unergatives as plain intransitives.
  – Transitive structures are plain transitive, i.e no small clause configuration for (a)telic transitives.
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• Transitive structures are plain transitive, i.e. no small clause configuration for (a)telic transitives.

(7)
• Restitutive *re*- prefixation distinguishes between unergative and transitive:

(8) a. John danced.
   b. *John re-danced.
   c. John re-danced a dance first performed by his distant ancestors.

• Restitutive *re*- prefixation distinguishes between transitives and SC:

(9) a. John re-shelved the books.
   b. *John re-put the books on the shelf.
• Denominal verb formation systematically resists argument interpretation of roots (Rimell, 2011)

(10) John caked last night. (hard to get ‘bake, make, eat’)

• Denominal verbs do not behave as if the root occupies the argument position. Their semantics is that of modifying the event introduced by v or the end state of a change of state syntactically projected as a direct object.
Verb compounds (outside synthetic noun compounds), where possible, resist argument interpretation of “incorporated” root.

(11) *Truck drive (i.e. ‘drive trucks’); cf. truck driver
ACEDO-MATELLÁN (2014)

• Against Marantz (2011):
  – (First) Merge as an operation that takes two objects and creates a first phrasal projection, by definition a structure involving a head and its complement.
ACEDO-MATELLÁN (2014)

• Against Marantz (2011):
  – Cross-linguistic data may support the distinction between roots as adjunct modifiers or complements.
    (12) a. Pauline smiled her thanks. (ADJUNCT)
    b. *La Paulina somrigué les gràcies. (Catalan)
    (13) a. The cow calved yesterday. (COMPLEMENT)
    b. La vaca vedellà ahir. (Catalan)
THE DEBATE

• H&K, AM&M: “Generative semantics” view.
  – Semantically unambiguous structures reflecting argument/event structure.

• Marantz: “Interpretive semantics” view of syntax.
  – Syntax does not start with a structure transparently representing argument/event structure.
SENTENCE TYPES

<table>
<thead>
<tr>
<th>VERB TYPE</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNERGATIVE VERB</td>
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<td>They sprayed a cookie sheet with vegetable oil.</td>
</tr>
</tbody>
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Table 1: Sentence types

- Selection based on frame frequency rates (VALEX), and lexical frequency (COCA).
- Unergatives: frame frequency lower than 0.15.
- Creation, Loc/Loc, With-SC: selected from among those with the highest frame frequency rate.
- Strong transitives: frame frequency higher than 0.83.
# TWO COMPETING GROUPING

<table>
<thead>
<tr>
<th>VERB TYPE</th>
<th>A-M/M</th>
<th>MARANTZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNERGATIVE VERB</td>
<td>v + v/DP</td>
<td>v</td>
</tr>
<tr>
<td>The dog barked in quiet parks at night.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COGNATE OBJECT</td>
<td>v + v/DP</td>
<td></td>
</tr>
<tr>
<td>The man dozed a restful doze on the train.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CREATION VERBS</td>
<td>v + SC</td>
<td>v + v/DP</td>
</tr>
<tr>
<td>He baked a delicious cake with spelt flour.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOCATION/LOCATUM</td>
<td>v + v/DP</td>
<td></td>
</tr>
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<td>They saddled a wild horse in the farm.</td>
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<td></td>
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<td>v + SC</td>
<td></td>
</tr>
<tr>
<td>He ignored a slight niggle in his knee.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WITH-SMALL CLAUSE</td>
<td>v + SC</td>
<td></td>
</tr>
<tr>
<td>They sprayed a cookie sheet with vegetable oil.</td>
<td></td>
<td></td>
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</tbody>
</table>

**Table 2: Sentence types and grouping by theory**
SYNTACTIC PRIMING

• The tendency to repeat or better process a sentence because of its structural similarity to a previously experienced, i.e. ‘prime’ sentence (Bock 1986).

# PRIMING CONDITIONS

<table>
<thead>
<tr>
<th>VERB TYPE</th>
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<th>MARANTZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 UNERGATIVE VERB</td>
<td></td>
<td>v</td>
</tr>
<tr>
<td>The dog barked in quiet parks at night.</td>
<td>v + v/DP</td>
<td></td>
</tr>
<tr>
<td>C2 COGNATE OBJECT</td>
<td>v + v/DP</td>
<td>v + v/DP</td>
</tr>
<tr>
<td>The man dozed a restful doze on the train.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3 CREATION</td>
<td>v + v/DP</td>
<td>v + v/DP</td>
</tr>
<tr>
<td>He baked a delicious cake with spelt flour.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4 LOCATION/LOCATUM</td>
<td>v + v/DP</td>
<td>v + v/DP</td>
</tr>
<tr>
<td>They saddled a wild horse in the farm.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C5 STRONG TRANSITIVES</td>
<td>v + SC</td>
<td>v + SC</td>
</tr>
<tr>
<td>He ignored a slight niggle in his knee.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6 WITH-SMALL CLAUSE</td>
<td>v + SC</td>
<td>v + SC</td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
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*Table 3: Priming conditions, sentence types and groupings by theory.*
STRUCTURAL PRIMING EXPERIMENT

• We test structural priming within and across sentence types.

• Self-paced reading language comprehension study over Mechanical Turk.

• Priming paradigm where each target item also serves as a prime sentence for the next target item (up to attention task or control condition – non-primed sentences).
SYNTACTIC PRIMING: PREDICTIONS 1

• Different structural priming predictions in terms of individual sentence types.
<table>
<thead>
<tr>
<th>PRIME</th>
<th>TARGET</th>
<th>AM&amp; M</th>
<th>MARANTZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1&gt;C2</td>
<td>UNERGATIVE</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>C1&gt;C3</td>
<td>UNERGATIVE</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>C2&gt;C1</td>
<td>COGNATE</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>C2&gt;C4</td>
<td>LOCATION/LOCATUM</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>C2&gt;C5</td>
<td>STRONG TRANSITIVE</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>C3&gt;C1</td>
<td>UNERGATIVE</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>C3&gt;C4</td>
<td>LOCATION/LOCATUM</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>C3&gt;C5</td>
<td>STRONG TRANSITIVE</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>C4&gt;C2</td>
<td>LOCATION/LOCATUM</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>C4&gt;C3</td>
<td>CREATION</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>C4&gt;C6</td>
<td>WITH-SMALL CLAUSE</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>C5 &gt; C2</td>
<td>STRONG TRANSITIVE</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>C5 &gt; C3</td>
<td>STRONG TRANSITIVE</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>C5 &gt; C6</td>
<td>WITH-SMALL CLAUSE</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>C6 &gt; C4</td>
<td>WITH-SMALL CLAUSE</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>C6 &gt; C5</td>
<td>STRONG TRANSITIVE</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
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<td>✓</td>
<td>x</td>
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<tr>
<td>C1&gt;C3</td>
<td>UNERGATIVE</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>C2&gt;C1</td>
<td>COGNATE</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>C2&gt;C4</td>
<td>COGNATE</td>
<td>x</td>
<td>✓</td>
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<tr>
<td>C2&gt;C5</td>
<td>COGNATE</td>
<td>x</td>
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<td>C3&gt;C1</td>
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<td>x</td>
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<td>✓</td>
<td>x</td>
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<tr>
<td>C5 &gt; C2</td>
<td>STRONG TRANSITIVE</td>
<td>x</td>
<td>✓</td>
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<td>x</td>
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</tr>
<tr>
<td>C5 &gt; C6</td>
<td>STRONG TRANSITIVE</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>C6 &gt; C4</td>
<td>WITH-SMALL CLAUSE</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>C6 &gt; C5</td>
<td>WITH-SMALL CLAUSE</td>
<td>✓</td>
<td>x</td>
</tr>
</tbody>
</table>
SYNTACTIC PRIMING: PREDICTIONS 2

• Different structural priming predictions in terms of groupings of sentence types by each theoretical approach.
GROUPING RELATIONS – PRIMING PREDICTIONS

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<tr>
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<th>AM&amp;M</th>
<th>MARANTZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1-C2-C3: UNERGATIVE – COGNATE – CREATION</td>
<td>✅</td>
<td>✗</td>
</tr>
<tr>
<td>C4-C5-C6: LOCATION/LOCATUM – STRONG TRANSITIVES – WITH SMALL CLAUSE</td>
<td>✅</td>
<td>✗</td>
</tr>
<tr>
<td>C2-C3-C4-C5: COGNATE – CREATION – LOCATION /LOCATUM – STRONG TRANSITIVES</td>
<td>✗</td>
<td>✅</td>
</tr>
</tbody>
</table>

*Table 5: Priming relations - Predictions by sentence groupings*
<table>
<thead>
<tr>
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<tr>
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<td>✓</td>
<td>✗</td>
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<td>C4-C5-C6       LOCATION/LOCATUM – STRONG TRANSITIVES – WITH SMALL CLAUSE</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>C2-C3-C4-C5    COGNATE – CREATION – LOCATION /LOCATUM – STRONG TRANSITIVES</td>
<td>✗</td>
<td>✓</td>
</tr>
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</table>

*Table 5: Priming relations - Predictions by sentence groupings*
NOTES ON STRUCTURAL PRIMING

• Surface vs. abstract structure priming
  – Bock et al. (1992), Pickering et al. (2002), Pickering & Ferreira (2009), Wittenberg et al. (2015), i.a.: syntactic priming is sensitive / attributable to surface structure.

• In both models, AM&M and MARANTZ, the proposed structures are surface structures.
PRIMING ACROSS MODALITIES

• Production vs. Comprehension (in behavioral studies)
  – Syntactic priming effects in production occur without lexical repetition and are enhanced when there is lexical boost, e.g. Pickering & Branigan (1998); Segaert et al. (2011, 2013).
  – Pickering & Branigan (1998): priming without lexical repetition only when primed with 2 sentences in production (completing sentence fragments).
PRIMING ACROSS MODALITIES

• Production vs. Comprehension (in behavioral studies)
  – Syntactic priming in **comprehension** seems to depend on *lexical boost*, e.g. Pickering & Traxler (2004); Branigan et al. (2005); Arai et al. (2007); Traxler & Tooley (2007); Tooley et al. (2009); Segaert et al. (2011, 2013).
  – Recent studies reporting syntactic priming in **comprehension** independent from *lexical boost*: Thothathiri & Snedeker (2008a,b); Traxler (2008); Pickering, McLean & Branigan (2013).
PRIMING IN COMPREHENSION

• Pickering & Traxler (2004): no priming in comprehension without lexical boost (eye tracking recording in reading task).

(14) The man watched by the woman was tall.
   a. \(=/=\) The child cleaned by the girl was covered in chocolate.
   b. \(==>\) The mouse watched by the cat was hiding under the table.
PRIMING IN COMPREHENSION

• Segaert et al. (2013): no syntactic priming in active sentences in the absence of lexical boost of head word (fMRI neuronal study of active and passive sentence comprehension and production).
PRIMING IN COMPREHENSION

• Thothathiri & Snedeker (2008): priming effects without lexical repetition in comprehension with 2 primed sentences (eye tracking identification plus acting out).

• Problems (reported in Tooley & Traxler 2010):
  – two prime sentences may reflect a task-specific effect,
  – kids had to act out target sentence with toys, invoking some covert production.
PRIMING IN COMPREHENSION

- Traxler (2008): first evidence of between-sentence structural priming in online sentence comprehension without lexical overlap, involving adjunct relations (eye-tracking).

(15) a. The chemist poured the fluid in the beaker into the flask earlier. (Same-structure PRIME)
b. The chemist poured the fluid into the flask earlier. (Different-structure PRIME)
c. The vendor tossed the peanuts in the box into the crowd during the game (TARGET).
PRIMING IN COMPREHENSION

- Pickering, McLean & Branigan (2013): structural priming in both lexically independent and lexically dependent comprehension (sentence-picture matching task of high and low-attachment ambiguous adjuncts).

(16) a. The policeman is thumping the soldier with the gun. (PRIME)

   b. The waitress is prodding the clown with the umbrella. (TARGET)
STIMULI IN STRUCTURAL PRIMING

• Garden-path sentences
  
  (17) The man accepted the price was not going to him. (Trueswell & Kim 1998)

• Ambiguous low and high-attachment adjuncts
  
  (18) The waitress is prodding the clown with the umbrella. (Pickering, McLean, Branigan 2013)
STIMULI IN STRUCTURAL PRIMING

• Double Object versus Dative constructions

  (19) a. Give the bird the dog bone.

  b. Give the bird house to the sheep. (Thothathiri & Snedeker 2008)
STIMULI IN STRUCTURAL PRIMING

• Datives versus Locatives versus Passives

  (20) a. The wealthy widow drove her Mercedes to the church.
      (PRIME)
  b. A rock climber sold some cocaine to an undercover agent.
      (TARGET) (Bock & Loebell 1990)

  (21) a. The foreigner was loitering by the broken traffic light.
      (PRIME)
  b. The referee was punched by one of the fans. (TARGET)
      (Bock & Loebell 1990)

• Actives versus Passives (e.g. Bock 1986; Segaert 2011, 2013)
PERSISTENCE OF PRIMING

• Hartsuiker et al. (2008): enhanced priming effect due to lexical boost does not persist across any number of intervening structures in production (picture description task).

• Carminati & van Gompel (2009): lexically dependent syntactic priming effects persist across 2 intervening sentences in comprehension (eye tracking identification task).
EXPERIMENTAL DESIGN

• 24 sentences of each condition (24 x 6 = 144), separated into 4 segments:
  – Subject
  – Verb
  – First Complement
  – Second Complement

• 1/6 of trials preceded by a two-choice comprehension question

• 3 blocks of trials, with 6 block orderings
  – Trials randomized within blocks
# SEGMENTS OF 4 PHRASES

<table>
<thead>
<tr>
<th></th>
<th>NP</th>
<th>V (+N/NP)</th>
<th>PP</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Unergative</td>
<td>The dog</td>
<td>barked</td>
<td>in the park</td>
</tr>
<tr>
<td>C2</td>
<td>Cognate</td>
<td>The dog</td>
<td>barked</td>
<td>a ferocious bark</td>
</tr>
<tr>
<td>C3</td>
<td>Creation</td>
<td>The man</td>
<td>built</td>
<td>a detached house</td>
</tr>
<tr>
<td>C4</td>
<td>Locative/Locatum</td>
<td>The man</td>
<td>caged</td>
<td>a young tiger</td>
</tr>
<tr>
<td>C5</td>
<td>Strong Transitive</td>
<td>The man</td>
<td>ignored</td>
<td>a slight niggle</td>
</tr>
<tr>
<td>C6</td>
<td>With-Small Clause</td>
<td>The man</td>
<td>crammed</td>
<td>a cigarette butt</td>
</tr>
</tbody>
</table>
STUDY IMPLEMENTATION

• Created in Ibex
  – Each segment presented sequentially in center of the screen
  – 400 ms between each sentence
  – Participants were shown instructions and completed a practice round before beginning
The army
flooded
a small river
in Austin.
Did they block it up or cross it?

1. cross it
2. block it up
STUDY IMPLEMENTATION

• Distributed via Amazon Mechanical Turk (500 HITs completed)
  – Restricted to participants in the U.S.
  – 95% or greater HIT acceptance rate
DATA PROCESSING

• Exclusion criteria:
  – Non-native English speakers
  – Multilinguals
  – < 70% overall accuracy
  – Duplicate participants

• n = 355 included participants
DATA PROCESSING

• Average reading time was calculated for each participant, for each segment:
  – Trials with RT > 2 standard deviations from participant’s respective mean were excluded.

• First trial of each block was excluded.
CONTROLLED ANALYSES

• Based on preliminary ANOVA results (6x6 within subjects; Factors: cond + prev_cond) and visual inspection of the plots, we decided to focus on the reading times of Segment 3, the first constituent after the verb (complement/adverbiaial).

• The analyses that follow will have Segment 3 reading time as the outcome/response variable.
ANCOVA
(Analysis of Covariance)

• We designed a mixed effects ANCOVA with random intercepts by subject and by item.

• ‘Nuisance’ variables included as covariates:
  – trial order,
  – verb frequency,
  – RT of previous segment,
  – RT of same segment in previous trial.
We coded two variables:

– Conditions recoded/grouped based on Marantz theory: Unergatives, DP/Root, Small Clause ($V_\alpha$)
– Conditions recoded/grouped based on AM&M theory: DP/Root, Small Clause ($V_\beta$)

These two variables were included as predictors in an ANCOVA model, with log-transformed frequency, trial order, previous trial RT, and previous segment RT as controls/covariates.
ANCOVA (1.0) – FINDINGS

• The full model was tested against models excluding each respective variable of interest.

• We found:
  – Significant contribution of Marantz model (p = .012)
  – Neither significant nor trending contribution of AM&M model (p = .1379)
AM&M vs. MARANTZ – By Condition

- No significant separation between conditions for the AM&M model – error bars overlap quite a bit.
- Significant separation in the Marantz model.
We created two new binary variables:

- Trials preceded by TWO trials of the same condition (same as each other, not as the current trial)
  - According to the Marantz theory ($V_\gamma$)
  - According to the AM&M theory ($V_\delta$

- Included the same control variables as in the previous ANCOVA models.
- We ALSO included the interaction of the two above variables ($V_\gamma, V_\delta$) with the variables associated with their respective models ($V_\alpha, V_\beta$).
ANCOVA (2.0) – FINDINGS

• The full model was tested against models excluding each respective interaction term.

• This gave a null result:
  – The contribution of the Marantz interaction was not significant (p = .649)
  – The contribution of the AM&M interaction was not significant (p = .863)
ANCOVA (2.0) – FINDINGS

• However, when we remove the random effects structure, keeping order as a covariate, we obtain significant effects
  – The contribution of the Marantz interaction was significant \((p = .0037)\)
  – The contribution of the AM&M interaction was not significant \((p = .756)\)

• Caution: Simplified model!
AM&M Model Prev2

- Differences in mean RT for Segment 3, by condition and previous condition for trials preceded by TWO trials of the same condition.
- None= Trials not preceded by 2 of the same condition.
No evidence that some set of V NP PP structures behave like SC or that unergatives look like transitives.
Marantz Model Prev2

- Differences in mean RT for Segment 3, by condition and previous condition for trials preceded by TWO trials of the same condition.
- None= Trials not preceded by 2 of the same condition.
Marantz Model Prev2

- We see effects for the SC condition. 2 SC sentences before a SC sentence causes a significant slow down in Segment 3 RTs, while 2 standard V NP PP sentences before SC causes a significant speed up in S3 reading.
ANCOVA – Limitations

• Limitations:
  – The AM&M variable, and thus the interaction including this variable, had fewer levels than the Marantz model, perhaps inherently restricting its ability to capture variance associated with this interaction.
  – However, adding more levels to the categorical predictor does not improve the analysis. The test of the ungrouped condition variable is still not significant (p = .11).
LINEAR MIXED EFFECTS REGRESSION MODEL

• To test priming on the basis of the grouping of conditions in each model.
• Same control variables as in previous ANCOVA analyses.
• We coded two additional binary variables based on the predictions of each model:
  – Primed
  – Unprimed
<table>
<thead>
<tr>
<th>PRIME</th>
<th>TARGET</th>
<th>AM&amp;M</th>
<th>MARANTZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1&gt;C2</td>
<td>UNERGATIVE</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>C1&gt;C3</td>
<td>UNERGATIVE</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>C2&gt;C1</td>
<td>COGNATE</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>C2&gt;C4</td>
<td>LOCATION/LOCATUM</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>C2&gt;C5</td>
<td>STRONG TRANSITIVE</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>C3&gt;C1</td>
<td>CREATION</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>C3&gt;C4</td>
<td>LOCATION/LOCATUM</td>
<td>✓</td>
<td>✗</td>
</tr>
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<td>C3&gt;C5</td>
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<td>✓</td>
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<td>C4&gt;C2</td>
<td>LOCATION/LOCATUM</td>
<td>✓</td>
<td>✗</td>
</tr>
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<td>C4&gt;C3</td>
<td>CREATION</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>C4&gt;C6</td>
<td>LOCATION/LOCATUM</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>C5 &gt; C2</td>
<td>STRONG TRANSITIVE</td>
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<td>✗</td>
</tr>
<tr>
<td>C5 &gt; C6</td>
<td>STRONG TRANSITIVE</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>C6 &gt; C4</td>
<td>WITH-SMALL CLAUSE</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>C6 &gt; C5</td>
<td>STRONG TRANSITIVE</td>
<td>✓</td>
<td>✗</td>
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<td>C6 &gt; C5</td>
<td>WITH-SMALL CLAUSE</td>
<td>✓</td>
<td>✗</td>
</tr>
</tbody>
</table>
LINEAR MIXED EFFECTS REGRESSION MODEL

• To test priming on the basis of the grouping of conditions in each model.
• Same control variables as in previous ANCOVA analyses.
• We coded two additional binary variables based on the predictions of each model:
  – Primed
  – Unprimed
• ✓ coded as 1
• ✗ coded as 0
LINEAR MIXED EFFECTS REGRESSION MODEL

• Results are not significant. However, the effect size for the Marantz model is consistently larger than that of AM&M.

• Without considering random effects:
  – Marantz model ($p = .1078$)
  – AM&M model ($p = .2999$)

• With random effects:
  – Marantz model ($p = .1766$)
  – AM&M model ($p = .565$)
LINEAR MIXED EFFECTS REGRESSION MODEL

- This is likely our most reliable model, because we have reduced the number of levels for the variables we are testing to just two for both models.
Marantz – Identity Priming Overall

- Conditions preceded by the same condition (just 1 previous trial), given the grouping of conditions in the Marantz model.
Marantz – Identity Priming By Condition

- Conditions preceded by the same condition (just 1 previous trial), given the grouping of conditions in the Marantz model by condition.
Marantz – Identity Priming By Condition 3 in a Row

- Conditions preceded by TWO same conditions (2 previous trials), given the grouping of conditions in the Marantz model by condition.
CONCLUSIONS

• Self-paced reading comprehension study shows syntactic priming effects with canonical (simple) NP V NP PP structures.

• ANCOVA 1.0: By Condition, we get significant effects of the Marantz model.

• ANCOVA 2.0: Interaction of Models with Prev_Two_Same, we get significant effects of the Marantz model with trial order and no random effects.
ONGOING QUESTIONS

• The inhibitory effect in slower RTs in conditions of priming.

• Limitations of the model variables in the number of levels (3 vs. 2) in the ANCOVAs, perhaps inherently conditioning their ability to capture variance.
NEXT STEPS

• More data are needed. Preliminary effects showing that the Marantz model is a better predictor are based on one aspect of the model, and we may not currently have enough statistical power to look at ALL aspects of the model.

• We had few trials preceded by 2 trials of the same condition as the current trial. We need more data to get reliable results in this direction.
Syntactic priming as a test of argument structure: A self-paced reading experiment

THANKS!

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