Structural Priming and Linguistic Representation

Martin Pickering
University of Edinburgh
This morning, I used structural priming to understand alignment in dialogue.

I now show it is informative about “traditional” psycholinguistic questions:

- Essentially, what are the representations and processes used by speakers (and listeners)?
- To study this, we make use of both dialogue and monologue.

And I use it to address questions usually associated with linguistics.
Question-answering

Pestering Dutch shopkeepers

– Q: *Om hoe laat gaat uw winkel dicht?* (“At what time does your shop close”?)
– A: *Om vijf uur* (“At five o’clock”)

– Q: *Hoe laat gaat uw winkel dicht?* (“What time does your shop close”?)
– A: *Vijf uur* (“Five o’clock”)

Levelt and Kelter (1982)
Priming unrelated sentences (Bock, 1986)

– In memory test, participant repeats sentence:

\[ \text{The rock star sold some drugs to the undercover agent (PO prime)} \]

– Makes recognition decision:

\[ \text{No} \]

– describes picture

\[ \text{The girl is handing the paintbrush to the man (PO target description)} \]
Priming unrelated sentences (Bock, 1986)

– In memory test, participant repeats sentence:
  *The rock star sold the undercover agent some drugs* (DO prime)

– Makes recognition decision:
  *No*

– describes picture
  *The girl is handing the man the paintbrush* (DO target description)
Procedure

• Confederate describes card: *The chef giving the jug to the swimmer*
• Participant finds the card that matches this description
• Participant picks up next card

• Participant describes card: “The cowboy handing …”
Same vs. different verb

• 4 prime conditions:
  PO-same: *The chef handing the jug to the swimmer*
  DO-same: *The chef handing the swimmer the jug*
  PO-different: *The chef giving the jug to the swimmer*
  DO-different: *The chef giving the swimmer the jug*

• Target:
  HAND
Results: % PO target

- Same verb
- Different verb

Bar chart showing the percentage of PO target for PO prime and DO prime under Same and Different verb conditions.
Priming when verb is not repeated

But stronger priming when it is repeated
  – Just as in monologue (Pickering & Branigan, 1998)
  – The **lexical boost** to priming

Also, semantic alignment enhances syntactic alignment

*the goat that’s pink* → *the sheep that’s pink*

MORE THAN

*the book that’s pink* → *the sheep that’s pink*
The chef giving the jug to the swimmer
The chef giving the jug to the swimmer
The chef giving the jug to the swimmer

Different verb (\textit{hand})

Syntactic priming
The chef giving the jug to the swimmer

Conceptual stratum

Lemma stratum

GIVE(X,Y,Z)

HAND(X,Y,Z)

give

hand

PO

DO

Same verb (give)

Syntactic priming + lexical boost
Priming and linguistics

- So what can priming tell us about linguistic representations?
- Priming as an alternative to grammaticality judgements

**Priming** measures similarity between sentences

A girl is stung by a bee  →  The glass was broken by a rock

- shared representation at some level
- is implicit (participants not aware of relationship)
- arguably involves direct relationship between representation and behaviour

- At very least: good additional method for experimental linguistics
Structural priming

Some aspect of structure is repeated between A and B
Structural priming

Some aspect of structure is repeated between A and B.
Syntactic priming

Some aspect of syntax is repeated between A and B
Syntactic priming

Branigan et al. (1995): priming can be informative about syntactic representation

- Based largely on 4 papers by Bock (1986-92)
- Syntactic priming implies syntactic similarity

Since then:

- Many constructions (active/passive, dative alternation, SOV/OSV order, NP structure…)
- Many languages (English, Dutch, Spanish, Mandarin, Korean…)
- Also between languages
- Many populations (adults, children, aphasics, amnesics, L2 learners…)
- Many methods (picture description, sentence completion, recall…)
- In both production and comprehension (and between them)
Syntactic priming

- Evidence of priming when alternatives do not differ in:
  - thematic roles, grammatical relations
  - constructional meaning or emphasis
  - Other aspects of structure (eg words, discourse register etc)

- aux-verb vs. verb-aux order (Hartsuiker & Westenberg, 2000)

  *Ik kon er niet door omdat de weg geblokkered was/was geblokkered*

  “I couldn’t pass through because the road blocked was/was blocked”

- NP + particle order (Konopka & Bock, 2009)
What picture does this give us?

- ‘shallow’ surface representations (surface order)
  - No evidence for underlying unordered constituent structure
    (Pappert & Pechmann, 2014; Pickering et al., 2002)

the girl gives to the man an extremely heavy dictionary

the teacher showed the map to the boy
What picture does this give us?

- ‘shallow’ surface representations (surface order)
  - No evidence for underlying ‘deep’ structure with moved elements (Bock & Loebell 1990)

The foreigner was loitering by the traffic light

The boy is being woken by the alarm clock

X The boy is being woken ___ by the alarm clock
What picture does this give us?

‘shallow’ surface representations (surface order)

- But some ‘empty’ elements are syntactically represented
  (Cai et al., 2015)

Niuzai mai-le yiben shu hou song-gei-le shuishou __

Niuzai mai-le yiben shu hou song-gei-le shuishou naben shu
Cowboy buy-PERF one book later give-PERF sailor that book

“The cowboy bought a book and later gave the sailor [ _ / that book]”

Jingcha di-gei shibing yiding maozi
policeman pass soldier one hat

“The policeman passes the soldier a hat”
What picture does this give us?

“Context-free” syntactic rules (Branigan et al., 2006)
- Priming between main clause ↔ embedded clause
  
  John said that the patient showed the doctor the wound
  The postman gave the woman the parcel

- Similar magnitude to priming within clause type

Representations are independent of thematic roles
(Bock & Loebell, 1990; Messenger et al., 2012):

Experiencer/Theme = Theme/Experiencer

The girl is being ignored by the bear / The girl is being scared by the bear

Agent-Patient passives

The king is being patted by the sheep
Syntactic priming: summary

*Janet says that a theory is proposed by every linguist*

*The enormous baby was kissed by the politician*

**Results suggest:**

- context-free syntax (local trees)  
  (Branigan et al., 2006)

- single ‘surface’ representation
  - No evidence for transformations— but some empty elements  
  (Bock & Loebell, 1990; Cai et al., 2015)
  - Specifies both order and dominance  
  (Pickering et al., 2002)
  - Does not encode thematic roles  
  (Bock & Loebell, 1990; Messenger et al., 2012)
(Non-syntactic) structural priming: semantic structure

Some aspect of semantic structure is repeated between A and B.
Thematic priming

Thematic relations don’t seem implicated in *syntactic* priming

But they affect *non-syntactic* structural priming

First evidence: Chang et al. (2003)

We now separate out different thematic effects

and use them to tell us about aspects of linguistic representation

assume priming between levels implies those levels are directly associated
Thematic representations

- Word order
- Thematic roles
- Grammatical functions
- Topichood
- Logical form
Thematic representations

- Word order
- Grammatical functions
- Logical form
-.Topichood

Thematic roles
Representation of thematic topic

A book is read by a linguist
Thematic topichood

- Priming occurs with unrelated constituent structure

Degene die hij slaat is de cowboy

‘The one who he is hitting is the cowboy’ (vs. ‘him is hitting…’)

- Passives (i.e., PATIENT-topic) (Vernice et al., 2012)

Door de bliksem wordt de kerk getroffen

‘by lightning is the church struck’ (vs Patient-initial passive)

- The alarm clock wakes the boy (Bernolet et al., 2009)
Thematic representations

- Word order
- Thematic roles
- Grammatical functions
- Logical form
- Topichood
Thematic order or function?

The man sprayed wax on the car

The workers scuffed dirt across the kitchen floor

The man sprayed the car with wax

The workers scuffed the kitchen floor with dirt

(Chang et al., 2003)

- not priming of constituent structure
  – thematic order? (Loc, Theme)
  – or thematic function? (Loc-DOBJ, Theme-OOBJ)
Thematic representations

- Thematic roles
- Word order
- Topichood
- Grammatical functions
- Logical form
Thematic order

Naben shu niuzai song-gei le shuishou
  book  cowboy  gave  sailor
  THEME  RECIPIENT

Jingcha song-le nading maozi gei shibing
  policeman  gave  hat  to  soldier
  THEME  RECIPIENT

( Compared to: Niuzaiz song-gei le shuishou
  RECIPIENT  naben shu
  THEME  V-NP-NP )

Priming of thematic order
- not constituent structure, thematic topichood, or thematic function

Cai et al., in press
Thematic representations

- Word order
- Topichood
- Grammatical functions
- Logical form

Thematic roles
Thematic function

Priming of thematic function
– not constituent structure, topichood or order*

[*other conditions rule this out]
Thematic representations

Word order

Grammatical functions

Logical form

Topichood

Thematic roles
Thematic scope

Every hiker climbed a hill

**Universal-wide interpretation:**

‘Every hiker climbed a hill (not necessarily the same hill)’

\[\forall x \ [hiker(x) \rightarrow \exists y \ [hill(y) \& \text{climb}(x,y)]\]  

**Existential-wide interpretation:**

‘There’s one specific hill that every hiker climbed’

\[\exists y \ [hill(y) \& \forall x \ [hiker(x) \rightarrow \text{climb}(x,y)]\]  

\[\exists y \ [hill(y) \& \forall x \ [hiker(x) \rightarrow \text{climb}(x,y)]\]
A tree was climbed by every child

∀x [child(x) → ∃y [tree(y) & climb(x,y)]

Every hiker climbed a hill
Thematic scope

Existential-wide interpretation:

A tree was climbed by every child

\[\exists y \ [\text{tree}(y) \land \forall x \ [\text{child}(x) \rightarrow \text{climb}(x,y)]]\]

Every hiker climbed a hill
Thematic scope

EXISTENTIAL-WIDE

A tree was climbed by every child

‘There’s one specific tree that every child climbed’

\[
\exists y \ [\text{tree}(y) \land \forall x \ [\text{child}(x) \rightarrow \text{climb}(x,y)]]
\]

Every hiker climbed a hill

‘There’s one specific hill that every hiker climbed’

\[
\exists y \ [\text{hill}(y) \land \forall x \ [\text{hiker}(x) \rightarrow \text{climb}(x,y)]]
\]
Not just repeated assignment of scope (e.g., repeated universal-wide scope)

A kid climbed every tree
$$\forall x \ [\text{tree}(x) \rightarrow \exists y \ [\text{child}(y) \ & \ \text{climb}(y,x)]]$$

Every hiker climbed a hill
$$\forall x \ [\text{hiker}(x) \rightarrow \exists y \ [\text{hill}(y) \ & \ \text{climb}(x,y)]]$$

- Not particular features of different pictures (ruled out in other experiment)
Not same scope applied to first NP or to same function

A tree was climbed by every child
‘There’s one specific tree that every child climbed’
\[\exists y \ [\text{tree}(y) \land \forall x \ [\text{child}(x) \rightarrow \text{climb} (x,y)]]\]

Every hiker climbed a hill
‘There’s one specific hill that every hiker climbed’
\[\exists y \ [\text{hill}(y) \land \forall x \ [\text{hiker}(x) \rightarrow \text{climb} (x,y)]]\]
Consistent with priming of scope-thematic role mappings

A tree THEME was climbed by every child
‘There’s one specific tree that every child climbed’
\[\exists y \ [\text{tree}(y) \land \forall x \ [\text{child}(x) \rightarrow \text{climb} (x,y)])]\n
Every hiker climbed a hill THEME
‘There’s one specific hill that every hiker climbed’
\[\exists y \ [\text{hill}(y) \land \forall x \ [\text{hiker}(x) \rightarrow \text{climb} (x,y)])]\n
Wide scope to Theme \rightarrow Wide scope to Theme
Non-syntactic structural priming: implications

- Priming of thematic role-word order mappings suggests a *direct* relationship between final constituent structure and thematic structure
  - i.e., no intervening levels

- Priming of thematic role-grammatical function mappings suggests that such functions must exist.
  - And they must form part of the constituent structure representation
Non-syntactic structural priming: implications

- Priming of thematic topic suggests a level of representation involving entities, their thematic roles, and topichood.

- Priming of thematic scope suggests a direct relationship between thematic roles and quantifier scope:
  - thematic representation intervenes between syntax and quantifier representation.
  - Logical Form is interpreted.
A book was read by every linguist

(There is one book such that every linguist has read it)

Semantic structure

\[ \exists y \left[ \forall x [\text{linguist}(x) \land \text{agent}(x)] \rightarrow [\text{book}(y) \land \text{theme}(y) \land \text{emphasis}(y) \land \text{read}(x,y)] \right] \]

Syntactic structure

A book was read by every linguist
A book was read by every linguist.

Semantic structure:

\[ \exists y \left[ \forall x [\text{linguist}(x) \& \text{agent}(x)] \rightarrow [\text{book}(y) \& \text{theme}(y) \& \text{emphasis}(y) \& \text{read}(x,y)] \right] \]
Thematic emphasis

∀x[linguist(x) & agent(x)] → [book (y) & theme (y) & emphasis (y) & read(x,y)]

Semantic structure

Syntactic structure

NP-SUBJ

NP-OOBB

A book was read

by every linguist
A book was read by every linguist

Semantic structure:
\[ \exists y \left[ \forall x \left[ \text{linguist}(x) \land \text{agent}(x) \right] \rightarrow \left[ \text{book}(y) \land \text{theme}(y) \land \text{emphasis}(y) \land \text{read}(x,y) \right] \right] \]

Syntactic structure:

Thematic scope

NP-SUBJ

A book was read

NP-OOBJ

by every linguist
Thematic function

A book was read by every linguist

Semantic structure

\[ \exists y \left[ \forall x [\text{linguist}(x) \land \text{agent}(x)] \rightarrow [\text{book}(y) \land \text{theme}(y) \land \text{emphasis}(y) \land \text{read}(x,y)] \right] \]

Syntactic structure

A book was read by every linguist
A book was read by every linguist.

Semantic structure:

$$\exists y \left[ \forall x [\text{linguist}(x) \land \text{agent}(x)] \rightarrow [\text{book}(y) \land \text{theme}(y) \land \text{emphasis}(y) \land \text{read}(x, y)] \right]$$

Syntactic structure:

NP-SUBJ

NP-OOBB

A book was read by every linguist
Conclusions

- Structural priming provides an alternative method for experimental linguistics
  - Based on (implicit) similarity
  - Potentially informative about any structural level:
    - Syntactic structure
    - Semantic structure
    - But also e.g., phonological structure
Conclusions

Specifically, we suggest structural priming provides evidence for:

- **syntactic representations**
  single level of linearised shallow constituent structure containing information about functional relations
  - no deep structure, no F structure, no unordered representation

- **thematic representations**
  including information about topichood
  - intervening between syntactic and quantifier representation

- **interpreted Logical Form**
  Compatible with Davidsonian/Parsonian view of semantic structure
  - LF is not directly related to constituent structure representation
Conclusions

Other recent/current work uses structural priming to draw inferences about representation of:

– ellipsis
– coerced structures
– strict vs sloppy readings etc
– bilingual syntax (shared crosslinguistic representations)

Potential to help distinguish between alternative theoretical accounts of various phenomena
Thank you
Priming with translation equivalents

- Priming within and between languages (4 experiments) using Dutch-English participants

- Strong lexical boost (in both Dutch and English)
  - More priming when prime and target verbs were repeated

- But also translation-equivalent boost (Dutch → English)
  - More priming when prime and target verbs had same meaning (e.g., *geven* + PO → *give* + PO)

- Similar results for Cantonese and Mandarin

Schoonbaert et al., 2007, JML
Cai et al., 2011, JML
Twice as much cross-linguistic priming when verbs mean the same thing

- lemmas are linked because they share a concept node

Schoonbaert et al, 2007, Experiment 2
The lemma stratum in bilinguals

Schoonbaert et al., 2007, JML
Polish (L1) → English (L2)

Sentence-Picture matching

- Sportowiec przygniata baletnicę
  (“The sportsman squashes the ballet dancer”, Active)
- Baletnica jest przygniatana przez sportowca
  (“The ballet dancer is squashed by the sportsman”, Passive)
- Baletnicę przygniata sportowiec
  (“The ballet dancer [obj] squashes the sportsman [subj], OVS)
- Baletnica i sportowiec
  (“The ballet dancer and the sportsman”, baseline)

Then describe another picture with English transitive

Fleischer et al., 2012
Polish → English priming

![Bar Chart](chart-image)

- Active
- Passive
- OVS
- Baseline

% Passives
Polish OVS sentences primed bilinguals to produce English passives
  – OVS primes behaved like passives
  – And led to more passives than baseline

OVS sentences and passives emphasize the patient
  – Cross-linguistic priming of thematic emphasis
  – A representation of thematic emphasis is shared across languages
Proficiency leads to shared representations

Do bilinguals share representations when the syntax is slightly different across languages?

(Flemish) Dutch has an *s*-genitive that is slightly different from the English *s*-genitive

*De non haar ei is geel*, “The nun her egg is yellow”
Is this shared with the English or not?

<table>
<thead>
<tr>
<th>(1a)</th>
<th>De non haar ei is geel</th>
<th>The nun’s egg is yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1b)</td>
<td>Het ei van de non is geel</td>
<td>The egg of the nun is yellow</td>
</tr>
</tbody>
</table>
Separate representations for Dutch and English ’s-genitives

Shared representations for Dutch and English ’s-genitives
Priming increased with proficiency
Also participants sometimes said

- *The nurse her shoe is green*
- but most often (32/42 trials) following Dutch *s*-genitive

We propose that participants initially have two constructions (possessive marker and pronominal), hence they don’t prime each other

Then they develop a shared ’s*-genitive

The “shared syntax” model (Hartsuiker et al., 2004) may represent an “end state” for proficient bilinguals