K. Bicknell, M. Kutas, T. P. Urbach, M. Hare, K. McRae, J. Elman

“EFFECTS OF EVENT KNOWLEDGE IN PROCESSING VERBAL ARGUMENTS” (2010)

Language Prediction and Integration (SS2013)
Alina Vasileuskaya
Outline

- Background and motivation

- Study and experiments
  - Norming studies: production norms, association norms, agent-patent priming
  - Experiment I: Self-paced reading
  - Experiment II: ERP

- Results

- Discussion
Event knowledge: thematic fit

Comprehenders can integrate information provided at multiple points in the sentence to engage event knowledge, which then, in conjunction with visual information guides anticipatory processing. (Kamide, Altmann, and Haywood, 1998)

The man will ride...
The girl will ride...

The man will taste...
The girl will taste...
Event knowledge: syntactic domain

Event knowledge exerts an immediate influence on syntactic expectations during incremental comprehension. Expectations for a reduced relative clause are affected by the status of the subject as a typical *agent* (1) or *patient* (2) of the initial verb. (McRae et al., 1998)

1) The **cop** arrested by the detective was guilty of taking bribes.
2) The **crook** arrested by the detective was guilty of taking bribes.
World and event knowledge

- Event knowledge is an important source of information used to guide semantic processing in real time.

- Wide variety of distinct information sources combine to allow comprehends not only to interpret the current input, but also to anticipate what is yet to come.

- Comprehension involves the computation of the relevant event and the roles of the participants in that event based on multiple cues available in the discourse.
Lexical retrieval vs. dynamic interpretation

Lexical retrieval
The verb’s lexical representation encodes information about typical *fillers* of its *thematic roles*, as well as information about *selectional restrictions* that the verb imposes on its arguments. ➔ When the verb is accessed it makes available information about appropriate role fillers.

Dynamic interpretation
Comprehenders dynamically compute an interpretation based on their knowledge of events and situations.
Study

General claim
Comprehenders do not merely retrieve meaning from a lexicon, but rather compute if from all available cues, of which event knowledge is one.

Hypothesis
Expectations regarding likely fillers of a patient role rely on event knowledge, and these expectancies are driven by multiple cues that are dynamically integrated during processing.
Study

Methods
Self-paced reading and ERPs measures

Manipulating the thematic fit of a patient noun by holding constant the verb and changing the agent noun to alter the interpretation of the event being described.

“It is difficult to envision how the potentially unbounded number of contexts that might be relevant could be anticipated and stored in the lexicon.” (Elman, 2009)
Self-paced reading

Goal
Test whether the choice of agent noun alters the event that a verb describes, leading comprehenders to anticipate a patient that is plausible for that specific event, rather than for the verb in general.

Participants
- 48 undergraduate students
- 31♀/17♂
- Mean age 21.4
Self-paced reading

Materials
50 verbs: each paired with 2 agent nouns that altered the scenario elicited by the agent-verb combination.
Production priming

Goal
Assess comprehenders’ knowledge of plausible patients for different events; obtain typical patient nouns given the agent-verb combination.

Questionnaire
50 pairs of questions
1 verb – 2 questions ➔ 5 responses

<table>
<thead>
<tr>
<th>List I</th>
<th>List II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who/what does a mechanic usually check?</td>
<td>Who/what does the journalist usually check?</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Ranked list of typical patient nouns for each agent-verb pair
Association norms

Goal
Rule out possibility that the agent directly facilitates the patient without any influence of the verb.

Single-response free association task
Provide a word that is strongly associated with the agent noun

32 verbs (2 agents, 2 patients)

Journalist  
check

Mechanic  
brakes
Agent-patient priming

Priming can be obtained even when prime-target pairs are not associated according to free association norms (Hare, Jones, et al. 2009):

*scissors – hair, razor – face, key – door*

**Goal**

Determine whether agent nouns facilitate their respective patient; rule out any *independent* facilitation of the patient by the agent noun.
Agent-patient priming

<table>
<thead>
<tr>
<th></th>
<th>List I</th>
<th>List II</th>
<th>List I</th>
<th>List II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related agent-patient pairs</td>
<td>Journalist-spelling</td>
<td>Mechanic-brakes</td>
<td>44</td>
<td>88</td>
</tr>
<tr>
<td>Unrelated agent-patient pairs</td>
<td>Mechanic-spelling</td>
<td>Journalist-brakes</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>*Related prime-target pairs</td>
<td>Coconut-pineapple</td>
<td>Closet-dresser</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>*Unrelated prime-target pairs</td>
<td>Closet-pineapple</td>
<td>Coconut-dresser</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Word-word filler pairs</td>
<td></td>
<td></td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>Word-nonword pairs</td>
<td></td>
<td></td>
<td>240</td>
<td></td>
</tr>
</tbody>
</table>

*Semantically-similar item pairs from McRae and Boisvert (1998) that produced facilitation to ensure that the priming could indeed be obtained.
Agent-patient priming

Short SOA (250ms) priming task
Lexical decision on the targets: indicate whether each target is a *word* or *nonword*.
Agent-patient priming: results

- Mean decision latencies for the congruent and incongruent agent-patient pairs were *identical* (509 ms)

- McRae and Boisvert’s items showed a significant 18 ms of *facilitation*

→ There was no evidence that the agents *independently* facilitated their patients.
Experimental materials

Production norms
Association norms
Agent-patient priming

32 agent-patient triples

Journalist – **check** – spelling; Mechanic – **check** – brakes
Speaker – **address** – group; Secretary – **address** – letter
Technician – **fix** – television; Cook – **fix** – lunch
Dancer – **twist** – ankle; Electrician – **twist** – cable
### Experimental sentences

<table>
<thead>
<tr>
<th>The</th>
<th>Agent</th>
<th>Verb</th>
<th>Det.</th>
<th>Patient</th>
<th>Post-patient region</th>
<th>Follow-up sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>The</td>
<td>journalist</td>
<td>checked</td>
<td>the</td>
<td>spelling</td>
<td>of his latest report to the editor.</td>
<td>His editor was a stickler for correct spelling and made everyone else at the paper obsess about it too.</td>
</tr>
<tr>
<td>The</td>
<td>mechanic</td>
<td>checked</td>
<td>the</td>
<td>spelling</td>
<td>of his latest report about the engine.</td>
<td>Not having much schooling, he strived to maintain professionalism at his shop.</td>
</tr>
<tr>
<td>The</td>
<td>mechanic</td>
<td>checked</td>
<td>the</td>
<td>brakes</td>
<td>on the car he had gotten earlier that day.</td>
<td>It turned out that the rear passenger-side brake was the source of the complaint.</td>
</tr>
<tr>
<td>The</td>
<td>journalist</td>
<td>checked</td>
<td>the</td>
<td>brakes</td>
<td>on the car he had gotten earlier that day.</td>
<td>The car had been acting strangely on the way to his interview.</td>
</tr>
</tbody>
</table>

**Congruent**

**Incongruent**

**Identical for congruent and incongruent versions**

**Plausible continuation to create a short story**
# Experimental materials

<table>
<thead>
<tr>
<th>List I</th>
<th>List II</th>
<th>List III</th>
<th>List IV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Journalist</strong> checked spelling…</td>
<td><strong>Mechanic</strong> checked spelling…</td>
<td><strong>Mechanic checked brakes…</strong></td>
<td><strong>Journalist checked brakes…</strong></td>
</tr>
<tr>
<td>Filler</td>
<td>Filler</td>
<td>Filler</td>
<td>Filler</td>
</tr>
<tr>
<td><strong>Electrician twisted his ankle…</strong></td>
<td><strong>Dancer twisted her ankle…</strong></td>
<td><strong>Dancer twisted the cable…</strong></td>
<td><strong>Electrician twisted the cable…</strong></td>
</tr>
<tr>
<td>Filler</td>
<td>Filler</td>
<td>Filler</td>
<td>Filler</td>
</tr>
</tbody>
</table>

- 4 lists (32 experimental sentences + 48 filler pairs)
- each verb only once
- congruent conditions = incongruent conditions
- yes-no comprehension question after each trial
Procedure

Word-by-word non-cumulative self-paced moving window reading paradigm.

--- ..... --- ---- ..... --- ---- --- ---- --- ---- --- ---- --- ----.

The --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ---.

--- journalist --- ---- --- --- ---- --- ---- --- ---- --- ---- --- ----.

--- ---- checked --- ---- --- ---- --- ---- --- ---- --- ---- --- ----.

--- ---- the --- ---- --- ---- --- ---- --- ---- --- ---- --- ----.

--- ---- spelling --- ---- --- ---- --- ---- --- ---- --- ---- --- ----.
Design

Critical regions

*The journalist checked the brakes on the car he…*
Self-paced reading: results

- There were no influence of congruence at the *patient* noun.
- Reading times were shorter in the *congruent* condition at the word directly following the patient as well as on the next word.

| Table 1 |
|------------------|------------------|------------------|------------------|
| Condition        | Region           | Spelling         | On               | His              |
|                  | Checked          | The              |                  |                  |
| Residual reading times |                  |                  |                  |                  |
| Incongruent      | 22 (7)           | 36 (5)           | −8 (6)           | 19 (6)           | 6 (5)            |
| Congruent        | 20 (7)           | 35 (4)           | −16 (4)          | −1 (4)           | −12 (3)          |
| Difference       | 2                | 1                | 8                | 20″              | 18″              |
| Raw reading times |                  |                  |                  |                  |                  |
| Incongruent      | 392 (15)         | 372 (12)         | 363 (16)         | 366 (14)         | 351 (13)         |
| Congruent        | 393 (15)         | 371 (10)         | 349 (13)         | 342 (12)         | 330 (11)         |
| Difference       | −1 (1)           | 1 (1)            | 14 (14)          | 24″              | 21″              |

*Note: Standard errors in parentheses.
* Significant.
Self-paced reading: results

Reading times on the two words immediately following the patient noun were shorter in the congruent condition, where they were consistent with the event evoked by the agent-verb pair.
Verb sense differences: subset analysis

Many of experimental verbs show clear *sense difference* that could result in *distinct lexical representation* for each sense: *break* – *leg* vs. *break* – *habit*; *fire* – *accountant* vs. *fire* – *rifle*; *grasp* – *saw* vs. *grasp* – *concept*...

Subset analysis
(17 verbs that do not show sense differences)

Same pattern: significant facilitation, and of the same magnitude as with the larger set, in the congruent condition in the post-patient and second post-patient region.

⇒ Differences in verb sense may reflect pragmatic relations, rather than lexical knowledge of individual verbs.
Self-paced reading: discussion

• Comprehenders assess the plausibility of a patient role-filler relative to a specific event at some stage in the comprehension process.

? But when does it exactly happen?

• Reliable reading time differences were observed starting with the word *followed* the patient noun rather than the patient itself.

? Does that mean that comprehenders do not make immediate use of event knowledge?
ERP experiment

Goal
Examine the time course of the effect of event knowledge

Expectations
Smaller N400 amplitude to the congruent (mechanic – check – brakes) than incongruent (journalist – check – brakes) patient.

Participants
12 undergraduate students
7♀/5♂
Mean age 20.5
ERP experiment

**Rapid serial visual presentation (RSVP)**

*The journalist checked the spelling of his latest report to the editor.*

```
+ The  200 ms

+      100 ms

+ journalist  200 ms

+      100 ms

...```
ERP experiment: results

There was a main effect of congruence in the N400 response to the *patient* noun, such that the *incongruent* condition was more *negative*.

Initial timing and scalp distribution were consistent with the canonical N400 congruity effect.
ERP experiment: discussion

The ERP data show significant difference between the congruent and incongruent conditions evident in the N400 response time-locked to the critical patient noun.

The mismatch between the results of both experiments indicates that ERP may be a more sensitive measure, registering differences which are not apparent in self-paced reading data.
General discussion

Comprehenders combine knowledge about an agent and a verb to influence their expectations for upcoming patient nouns.

What *type of knowledge* may they use to do this?

1. Lexical knowledge
2. Knowledge of statistical linguistic regularities
3. Knowledge of typical events
1. Lexical knowledge

The lexicon includes multiple entries for each verb, each corresponding to a *verb’s sense*.

*check*(1) – inspect mechanical objects  
*check*(2) – verify the correctness of smth.

There are no verb sense differences for the majority of experimental items ➔ Lexical information alone would not be sufficient.
2. Knowledge of statistical linguistic regularities

**Topic models**

Words provide evidence for the topic underlying a particular discourse, and the inferred likely topic can be used to predict upcoming words.

 générails

⚠️ N400 effects in discourse are influenced by *precise constraints of the message*, rather than a scenario suggested by a few of the content words.
3. Event knowledge

Comprehender encounters certain linguistic material and activates knowledge of a likely class of events.

Once this event is activated, the comprehender’s knowledge of typical events facilitates processing of words congruent with the event.
Event knowledge plays an important role in language interpretation.

The choice of agent noun can shade the interpretation of the event that the verb evokes, and this, in turn, influences the processing about the upcoming patient.

Comprehenders immediately and dynamically compute a context-dependent interpretation based on all available cues, including their knowledge of typical events and situations in the world.
## Challenges

<table>
<thead>
<tr>
<th></th>
<th>Rayner et al., 2004</th>
<th>Matsuki et al., 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Method</strong></td>
<td>Eye tracking</td>
<td>Self-paced reading; eye tracking</td>
</tr>
<tr>
<td><strong>Material:</strong></td>
<td><strong>Instrument-Action-Patient</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plausible: <em>John used a knife to chop the carrots.</em></td>
<td>Typical:</td>
</tr>
<tr>
<td></td>
<td>Implausible: <em>John used an axe to chop the carrots.</em></td>
<td><em>a) Donna used the hose to wash her car.</em></td>
</tr>
<tr>
<td></td>
<td>Anomalous: <em>John used a pump to inflate the carrots.</em></td>
<td><em>b) Donna used the shampoo to wash her hair.</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Atypical:</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>a) Donna used the shampoo to wash her car.</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>b) Donna used the hose to wash her hair.</em></td>
</tr>
<tr>
<td><strong>Results</strong></td>
<td>• <strong>Delayed effects of plausibility</strong> with no difference between the plausible and implausible conditions at the patient itself.</td>
<td>• <strong>Immediate effects of plausibility</strong> on the patient noun in self-paced reading, first fixation, and gaze duration measures.</td>
</tr>
<tr>
<td></td>
<td>• Immediate effect of anomaly on the patient and two following words in the anomalous condition.</td>
<td></td>
</tr>
<tr>
<td><strong>Interpretation</strong></td>
<td><strong>Lexical retrieval account</strong></td>
<td><strong>Immediate and dynamic use of event knowledge</strong></td>
</tr>
</tbody>
</table>
Final remarks and open questions

• Timing of plausibility effects is not fully understood and has to be further investigated (Instrument-verb-patient plausibility manipulations in Rayner et al., 2004 vs. Matsuki et al., 2011).

• The exact relationship between the motor commands initiating self-paced reading responses and generators of ERP components such as the N400 remains unclear.

• It seems to be difficult to draw a distinct line between lexical priming and event knowledge activation.

• Although the authors do not support the lexical retrieval account and favor dynamic interpretation based on event knowledge, the study does not provide cogent evidence in defense of the latter.
Discussion

• What do you think about stimuli design and experimental setup? Can we still argue that the overall effect is driven by lexically defined sense differences?

• Do norming studies exclude independent word-word facilitation and reflect comprehenders’ generalized event knowledge?

• Does the comprehenders’ world knowledge narrow domain of discourse facilitating prediction in the same way as visual/linguistic context does?
Discussion

• Do comprehenders use their knowledge of events and situations in an anticipatory or integrative fashion?

• Can you think of other cues that might be used in discourse comprehension to predict upcoming words?

• What is your opinion on the three accounts of the type of knowledge that comprehenders may use to generate their expectations for upcoming words?