Misalignment of offline and online measures in Russian relative clause processing

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• Sentence comprehension is the computation of meaning.

• How does the manipulation of symbols (words, morphemes, phrases) produce meaningful interpretations in our minds?

• Are the mental grammar and language processing parts of the same system?
Response types

Online responses:
• use time-sensitive measures
• usually as the structure unfolds
• complemented by accuracy on comprehension questions presented after the sentence disappears

Offline responses:
• judgments made with no time limits
• usually after the full structure is presented
Online vs. offline responses

• **What stages of computation do these offline and online responses reflect?**

• Online responses show intermediate steps in building grammatical representations, offline judgments reflect different stages of computation in the same system (Lewis & Phillips, 2015; Phillips & Lewis, 2013).

• Attempts to establish how grammar and language processing could be part of the same cognitive system have called for comparisons of offline and online responses to the same input.
The present study

- investigated how online and offline responses complement each other by examining the processing of Russian relative clauses (RCs) with
  - offline measures:
    acceptability judgment task
    complemented by a corpus analysis
  - online measures:
    2 self-paced reading experiments
    complemented by a comprehension question accuracy measure
The housewife, who upset the old lady, lay on the couch in the living room.

1 (completely unacceptable) - 2 (not fully acceptable) - 3 (somewhat acceptable) - 4 (acceptable) - 5 (completely acceptable)
Online measures (in ms): Self-paced reading
Online measures (in ms): Self-paced reading

Housewife,
Online measures (in ms): Self-paced reading

---------------------who.nom ---------------------
Online measures (in ms): Self-paced reading

after walk
Online measures (in ms): Self-paced reading

-----------------------------------------old_lady.acc ------------------------------------------
------------------------------------------.
Online measures (in ms): Self-paced reading
Online measures (in ms): Self-paced reading

-------------------------------------------------------------------------upset
-------------------------------------------------------------------------
Online measures (in ms): Self-paced reading

with her story,
Online measures (in ms): Self-paced reading

lay------------------------.
Online measures (in ms): Self-paced reading

----on couch in living_room.
Online measures: Comprehension question

Did the housewife upset the old lady with her story?

NO  YES
Online measures: Comprehension question

CORRECT
Relative clause processing

Studies on relative clauses (RCs) in a number of languages have shown that object-extracted RCs (ORCs) are more difficult to process than subject-extracted RCs (SRCs).

Subject-extracted RC (SRC):

a. The reporter$_1$ [that $t_1$ attacked the senator] admitted the error.

Object-extracted RC (ORC):

b. The reporter$_1$ [that the senator attacked $t_1$] admitted the error.

A number of studies have shown that ORCs are more difficult to process not just in English, but also in other languages, including Chinese, Dutch, Hungarian, Japanese and others (Staub, 2010; Traxler et al., 2002; Traxler et al., 2005; MacWhinney & Pleh, 1998; Mak et al., 2002; Lin & Bever, 2006; Miyamoto & Nakamura, 2003).
Relative clause processing

Models of the SRC-ORC processing asymmetry:

• **Expectation-based accounts** (Hale, 2001; Levy, 2008; Reali & Christiansen, 2007; MacDonald & Christiansen, 2002)
  - NOMINAL RCs (with a descriptive NP inside the RC):
  - PRONIMINAL RCs (with a pronoun inside the RC):

• **Memory-based accounts** (King & Just, 1991; Gibson, 1998, 2000; Gordon et al., 2001; Johnson et al., 2011)
  - integration costs depend on distance, number and types of NPs to be held in working memory, NP similarity

• **Structure-based accounts** (MacWhinney & Pleh, 1998; Lin & Bever, 2006; Clifton & Frazier, 1989)

• **Hybrid accounts** (Staub, 2010; Levy et al., 2013)
  - a combination of these factors
The present study

• In many languages, word order differences between SRCs and ORCs make it difficult to test among these accounts.

  SRC:
  a. The reporter₁ [that t₁ attacked the senator] admitted the error.

  ORC:
  b. The reporter₁ [that the senator attacked t₁] admitted the error.

• Russian allows SRCs and ORCs to have the same lexical material in the same linear order (with case-marking distinguishing between RC types).
The sentences of interest (see Handout)

<table>
<thead>
<tr>
<th>(1a) SRC [embedded-clause word order: OV (scrambled)]</th>
<th>EX 1/ dispreferred/ preferred word order</th>
<th>EX 2 word order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hozyaika, / kotoraya.NOM</td>
<td>posle progulki</td>
<td>starushku / menyas [nas].ACC</td>
</tr>
<tr>
<td>Housewife, / who.NOM</td>
<td>after walk</td>
<td>old Lady / me (us).ACC</td>
</tr>
</tbody>
</table>

“The housewife, who after the walk really upset the old lady/me with the story, lay on the couch in the living room.”

<table>
<thead>
<tr>
<th>(1b) Control (CC) for SRC [embedded-clause word order: OVS (scrambled)]</th>
<th>dispreferred/ preferred word order</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hozyaika / skazala, / chto</td>
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“The housewife said that after the walk the aunty really upset the old lady/me with the story.”

<table>
<thead>
<tr>
<th>(2a) ORC [embedded-clause word order: SV (default)]</th>
<th>dispreferred/ preferred word order</th>
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<tbody>
<tr>
<td>Hozyaika, / kotoruyu.ACC</td>
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“The housewife, whom after the walk the old lady/I really upset with the story, lay on the couch in the living room.”

<table>
<thead>
<tr>
<th>(2b) Control (CC) for ORC [embedded-clause word order: SVO (default)]</th>
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“The housewife said that after the walk the old lady/I really upset the aunty with the story.”
The sentences of interest (see Handout)

(1a) SRC [embedded-clause word order: OV (scrambled)]

Hozyaika, / kotoraya.NOM / posle progulki / starushku / menya (nas).ACC
Housewife, / who.NOM / after walk / old_lady / me (us).ACC

“The housewife, who after the walk really upset the old lady/me with the story, lay on the couch in the living room.

(1b) Control (CC) for SRC [embedded-clause word order: OVS (scrambled)]

Hozyaika / skazala, / chto / posle progulki / starushku / menya (nas).ACC
Housewife / said, / that / after walk / old_lady / me (us).ACC

“The housewife said that after the walk the aunty really upset the old lady/me with the story.”

(2a) ORC [embedded-clause word order: SV (default)]

Hozyaika, / kotoruyu.ACC / posle progulki / starushka/ ya (mi).NOM
Housewife, / who.ACC / after walk / old_lady/ I (we).NOM

The housewife, whom after the walk the old lady/I really upset with the story, lay on the couch in the living room.

(2b) Control (CC) for ORC [embedded-clause word order: SVO (default)]

Hozyaika / skazala, / chto / posle progulki / starushka/ ya (mi).NOM
Housewife / said, / that / after walk / old_lady/ I (we).NOM

“The housewife said that after the walk the old lady/I really upset the aunty with the story.”
The sentences of interest (see Handout)

- an NP argument intervened between the modified noun and the RC verb: NP-O/S + V
The sentences of interest (see Handout)

- the same number of NP arguments was available for integration at the RC verb, across the same linear distance, in both SRCs and ORCs

EX 1

<table>
<thead>
<tr>
<th>Dispreferred/ preferred word order</th>
</tr>
</thead>
<tbody>
<tr>
<td>starushka / meny (nas).ACC</td>
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<tr>
<td>old_lady / me (us).ACC</td>
</tr>
<tr>
<td>silno / upset</td>
</tr>
<tr>
<td>rasstroila / svoim rasskazom,</td>
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</tbody>
</table>

EX 2

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<tr>
<td>silno / upset</td>
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<tr>
<td>rasstroila / svoim rasskazom,</td>
</tr>
</tbody>
</table>

(1a) SRC [embedded-clause word order: OV [scrambled]]

Housewife, kotoraya.NOM | posle proguiki | after walk |
Hozyaika,                   | starushka / meny (nas).ACC |

(1b) Control (CC) for SRC [embedded-clause word order: OVS [scrambled]]

Housewife | said, | that | after walk |
Hozyaika | skazala, | chto | posle proguiki |

(2a) ORC [embedded-clause word order: SV [default]]

Hozyaika, kotoruyu.ACC | posle proguiki |
Housewife, who.ACC | after walk |

(2b) Control (CC) for ORC [embedded-clause word order: SVO [default]]

Housewife | said, | that | after walk |
Hozyaika | skazala, | chto | posle proguiki |

"The housewife, whom after the walk the old lady/I really upset with the story, lay on the couch in the living room.

"The housewife said that after the walk the old lady/I really upset the aunty with the story."

25
The sentences of interest (see Handout)

- the influence of structural expectations was investigated by using different NP types -- descriptive NPs and pronouns -- inside the embedded clause
Russian corpus analysis

Percentages of SRCs and ORCs with different word orders depending on embedded NP type
Russian corpus analysis

Percentages of SRCs and ORCs with different word orders depending on embedded NP type

![Graph showing percentages of SRCs and ORCs with different word orders depending on embedded NP type. The graph indicates that nominal NPs are predominantly in the default order (VO/SV), while pronominal NPs have a higher proportion of scrambled order (OV/VS).]
Russian corpus analysis

Percentages of SRCs and ORCs with different word orders depending on embedded NP type
Russian corpus analysis

Percentages of SRCs and ORCs with different word orders depending on embedded NP type

![Graph showing percentages of SRCs and ORCs with different word orders depending on embedded NP type.

- SRC (100%):
  - Nominal: 95%
  - Pronominal: 5%

- ORC (100%):
  - Nominal: 20%
  - Pronominal: 80%

Legend:
- Default (VO/SV)
- Scrambled (OV/VS)
Russian corpus analysis

Percentages of SRCs and ORCs with different word orders depending on embedded NP type
An offline acceptability judgment study

Mean rating scores for RCs with different word orders inside the embedded clause

![Bar chart showing mean rating scores for RCs with different word orders inside the embedded clause. The chart compares Nominal SRC, Pronominal SRC, Nominal ORC, and Pronominal ORC. The default (VO/SV) and scrambled (OV/VS) conditions are compared. The scores range from 2.5 to 4.5.]
An offline acceptability judgment study

Mean rating scores for RCs with different word orders inside the embedded clause

Mean rating scores

Nominal	Pronominal
Default (VO/SV)  Scrambled (OV/VS)

SRC

ORC
An offline acceptability judgment study

Mean rating scores for RCs with different word orders inside the embedded clause
An offline acceptability judgment study

Mean rating scores for RCs with different word orders inside the embedded clause
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Mean rating scores for RCs with different word orders inside the embedded clause

Mean rating scores

<table>
<thead>
<tr>
<th>SRC</th>
<th>Nominal</th>
<th>Pronominal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default (VO/SV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrambled (OV/VS)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ORC</th>
<th>Nominal</th>
<th>Pronominal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default (VO/SV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrambled (OV/VS)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Corpus frequencies vs. Acceptability scores

![Graph showing corpus frequencies vs. acceptability scores for nominal vs. pronominal structures in SRC and ORC, with default (VO/SV) and scrambled (OV/VS) conditions.]
An offline acceptability judgment study

Mean rating scores for CCs with different word orders inside the embedded clause.

- **Nominal**
- **Pronominal**

<table>
<thead>
<tr>
<th>SRC Control CC</th>
<th>Default (SVO)</th>
<th>Scrambled (OVS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal</td>
<td>4.0 ± 0.5</td>
<td>3.5 ± 0.5</td>
</tr>
<tr>
<td>Pronominal</td>
<td>4.2 ± 0.5</td>
<td>3.8 ± 0.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ORC Control CC</th>
<th>Default (SVO)</th>
<th>Scrambled (OVS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal</td>
<td>4.1 ± 0.5</td>
<td>3.6 ± 0.5</td>
</tr>
<tr>
<td>Pronominal</td>
<td>4.3 ± 0.5</td>
<td>4.0 ± 0.5</td>
</tr>
</tbody>
</table>
• How does the offline data correspond to the online measures?
Online vs. Offline measures (Nominal RCs)

• Some indications of online processing difficulty patterned with the offline measures, but others did not.

RC sentences - Acceptability Judgment

CC control sentences - Acceptability Judgment
Online Self-paced Reading Experiment 1 (Nominal RCs)

Expectation effects => alignment

Sentence Type*
SRC = SRC Control \( > \) ORC \( > \) ORC Control

Clause Type ***
RCs \( > \) CCs

Memory effects => misalignment

who.NOM/ACC\( \ldots \) that kotoraya{-yu}) \( \ldots \) chto
R2 RelPro/Comp

after walk posie progulki
R3 SpillR1

old_lady.ACC/NOM starushku{-a}
R4 RC NP/CC NP

really sino
R5 SpillR2

upset rasstroila
R6 RCVerb/CC Verb

with her story... svoim rasskazom...
R7 SpillR3
Online vs. Offline measures (Pronominal RCs)

- Some indications of online processing difficulty patterned with the offline measures, but others did not.
Online Self-paced Reading Experiment 2 (Pronominal RCs)

Expectation effects => alignment

Memory effects => misalignment

Clause Type **
RCs > CCs

Processing cost for SRC Control:
Sentence Type* interaction*

who.NOM/ACC...that
kotoraya(-uš) i... chto
R2
RelPro/Comp

after walk
posle progulki
R3
SpillR1

me (us)/ACC/I (we)NOM
menya (nas)/ye (mi)
R4
RC NP/CC NP

really
sino
R5
SpillR2

upset
rastroila
R6
RC Verb/CC Verb

with her/my(our) story...
svoim rasskazom...
R7
SpillR3
Online vs. Offline measures

**Online = Offline => alignment**

For sentences that were dispreferred in offline judgments and less frequent in the corpus, longer reading times were revealed at the first unexpected word -- the embedded-clause NP.

**Online ≠ Offline => misalignment**

The RC vs. CC pattern of expectation effects does not continue on throughout the sentence.

Comparable integration costs for SRCs and ORCs at/after the RC verb when distance and the types of integrated elements were held constant.
Comprehension question measure => misalignment

- Although ORCs with descriptive NPs were judged offline as more acceptable than SRCs, and were found to be more frequent in the corpus...
Comprehension question measure => misalignment

- Late-stage comprehension difficulty was revealed for nominal ORC sentences in particular

<table>
<thead>
<tr>
<th></th>
<th>EX 1 NOMINAL</th>
<th>EX 2 PRONOMINAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRC RC</td>
<td>15.6%</td>
<td>11.9%</td>
</tr>
<tr>
<td>SRC control CC</td>
<td>19.0%</td>
<td>5.8%</td>
</tr>
<tr>
<td>ORC RC</td>
<td>28.1%</td>
<td>9.0%</td>
</tr>
<tr>
<td>ORC control CC</td>
<td>13.5%</td>
<td>6.3%</td>
</tr>
<tr>
<td>Sentence Type</td>
<td>$</td>
<td>z</td>
</tr>
<tr>
<td>Clause Type</td>
<td>$</td>
<td>z</td>
</tr>
<tr>
<td>Interaction</td>
<td>$</td>
<td>z</td>
</tr>
</tbody>
</table>

- This suggests that similarity-based interference (Gordon et al., 2001, 2002, 2004, 2006), combined with ORC structural processing difficulty, also influences processes related to retrieving and assigning thematic roles to NPs during RC processing.
Interpretation of results

• These results thus suggest that
  – intermediate steps in online structure building related to expectation-based processing correspond to offline measures,
  – whereas online processing disruptions and comprehension difficulty that appear to relate to memory demands do not.

• Online measures reflect intermediate stages of computation that offline measures are not able to show.

• These differences between the online and offline results might be taken to reflect different stages of computation in a single cognitive system for language processing.
Thank you!
References


References


