

### Background & Motivation

What determines the difficulty of comprehending a verb embedded inside a relative clause?

Many theories, each with some type of empirical support, make differing predictions as to processing difficulty patterns at the verb inside an RC:

- **Locality:** a verb is more difficult when it requires the simultaneous integration and/or retrieval of multiple dependencies (Gibson 1998, 2000)
- **Expectations:** a verb is easier when the preceding context provides constraints (syntactic, valence, semantic...) that help sharpen the comprehender's expectations about *when* the verb is likely to appear and *what* it is likely to be (Konieczny 2000, Levy 2005).
- **Entropy reduction hypothesis (ERH):** if a verb causes a sharp reduction in uncertainty regarding the rest of the sentence, it gives rise to processing difficulty (Hale 2003).
- **Similarity-based interference (SBI):** processing difficulty can ensue when multiple NPs preceding the verb are superficially good matches to a given argument slot of the verb (Lewis 1996, Van Dyke & Lewis 2003).
- **Perspective Shift:** when the relativized head noun's external and internal grammatical functions (GF) are different, the required perspective shift is costly (MacWhinney, 1977, 1982; MacWhinney & Pleh, 1988; cf. Bever, 1970).
- **Word-order theories:** canonical vs. non-canonical word order in the RCs (MacDonald & Christiansen, 2002; cf. Bever, 1970; Mitchell et al., 1995; Tabor, Juliano & Tanenhaus, 1997).

#### Experimental methods:

Experiment 1: self-paced reading study, 40 native Russian speaker participants (5 removed due to low question-answering accuracy), conducted in Volgograd, Russia

Experiment 2: self-paced reading study, 40 native Russian speaker participants, conducted in Kazan, Moscow, and St. Petersburg, Russia

### Experiment 1

Goal:

Investigate the effect on processing difficulty of both extraction type and word order (closeness to canonical SVO) within Russian relative clauses.

Materials:

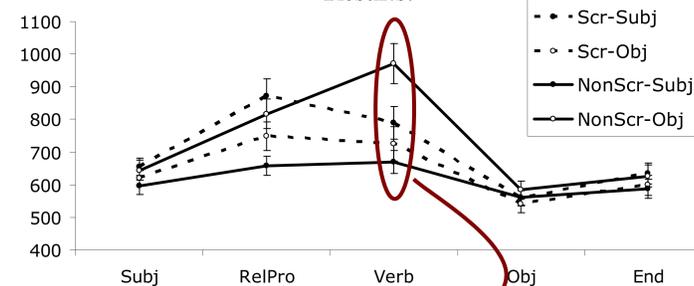
**NonScr-Subj [SVO]**  
Diktator kotorij nenavidel dissidenta proiznes rech na sobranii  
dictator who-Nom hated dissident-Acc gave speech at meeting  
'The dictator who hated the dissident gave a speech at the meeting'

**NonScr-Obj [OSV]**  
Diktator kotorogo dissident nenavidel proiznes rech na sobranii  
dictator who-Acc dissident-Nom hated gave speech at meeting  
'The dictator who the dissident hated gave a speech at the meeting'

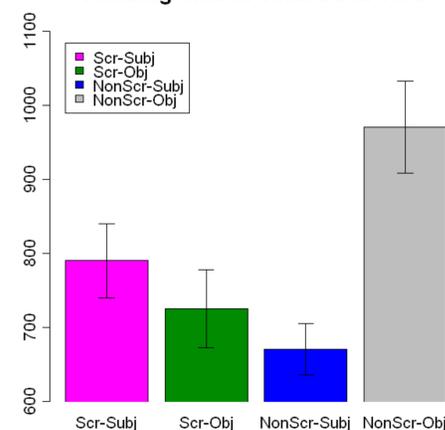
**Scr-Subj [SOV]**  
Diktator kotorij dissidenta nenavidel proiznes rech na sobranii  
dictator who-Nom dissident-Acc hated gave speech at meeting  
'The dictator who hated the dissident gave a speech at the meeting'

**Scr-Obj [OVS]**  
Diktator kotorogo nenavidel dissident proiznes rech na sobranii  
dictator who-Acc hated dissident-Nom gave speech at meeting  
'The dictator who the dissident hated gave a speech at the meeting'

Results:



Reading time at embedded verb



- Significant main effect of extraction type (both  $p < 0.05$ )
  - When word order is viewed in terms of canonicity, a significant crossover interaction (both  $p < 0.01$ ):
    - for subject-extracted RCs, the non-scrambled SVO condition is easier
    - for object-extracted RCs, the scrambled OVS condition is easier
- These results are consistent with locality-based predictions, but inconsistent with the predictions of word-order theories.

### Experiment 2

Goal:

Parametrically vary the number and type of dependents preceding the embedded verb in *subject-extracted* RCs. Contrasts locality-based predictions (more dependents → more difficulty) with expectation-based and ERH-based predictions.

Base case:

...ofitsiant, kotorij zabyl prinesti bljudo iz teljaty  
...waiter, who.Nom forgot to\_bring [acc.dish of\_veal]  
posetitelju v\_ chernom\_kostjume vovremja, ...  
[NP<sub>dat</sub> guest in\_black\_suit] on\_time, ...

"...the waiter who forgot to bring the veal dish to the guest in the black suit on time..."

Schematic structure (adjacent dependency):

0: N, who verb\_complex NP<sub>acc</sub> NP<sub>dat</sub> ...

Argument manipulation:

0: N, who verb\_complex NP<sub>acc</sub> NP<sub>dat</sub> ...  
1: N, who NP<sub>acc</sub> verb\_complex NP<sub>dat</sub> ...  
2: N, who NP<sub>acc</sub> NP<sub>dat</sub> verb\_complex ...

Adjunct manipulation:

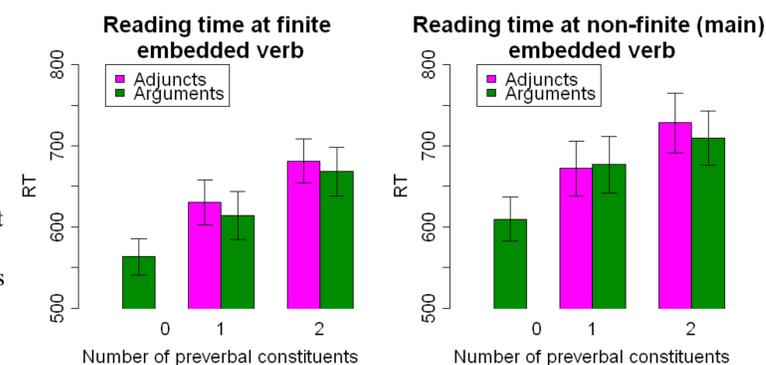
0: N, who verb\_complex NP<sub>acc</sub> NP<sub>dat</sub> ...  
1: N, who TMP1 verb\_complex NP<sub>acc</sub> NP<sub>dat</sub> ...  
2: N, who TMP1 TMP2 verb\_complex NP<sub>acc</sub> NP<sub>dat</sub> ...

(In the example above, *TMP1*="early evening", *TMP2*="around six")

In the adjunct manipulation, we controlled the position within the sentence where the verb complex appears by moving the temporal phrases not appearing inside the RC into the first clause of a sentence-level coordination.

Results at verb complex:

Increasing numbers of preverbal dependents consistently increase reading time at the embedded verb complex.



all 1x3 contrasts significant at (at least)  $p < 0.05$

### Corpus study

Goal:

To ensure that expectations about the upcoming verb really *should* be sharpened by additional preverbal dependents, we conducted a corpus study of subject-extracted Russian relative clauses modifying animate masculine head nouns and beginning with the unambiguously nominative relative pronoun *kotorij* (n=216), using the Uppsala corpus.

Results:

When either an NP or temporal dependent intervenes between *kotorij* and embedded verb, the conditional probability of the next constituent being a verb increases significantly ( $p < 0.01$  for NP interveners,  $p < 0.025$  for TMP).

At the syntactic level, at least, the additional preverbal dependents in Experiment 2 should help sharpen comprehenders' expectations about the upcoming verb (c.f. Jaeger et al. 2005).

Conditional Probability	Support	Event prob.
P(V   <i>kotorij</i> )	216	0.50
P(V   <i>kotorij</i> , NP)	13	0.85
P(V   <i>kotorij</i> , TMP)	19	0.79

### Conclusions

These data lend strong support to a locality-based component of processing difficulty at the embedded verb in Russian relative clauses:

- Positioning an additional dependent in between the relative pronoun and the embedded verb increases verbal processing difficulty in both subject- and object-extracted RCs
  - In subject-extracted RCs, the more dependents intervene, the greater the processing difficulty at the embedded verb
  - Argument and adjunct interveners have similar effects on processing difficulty at the embedded verb
- Other theories, in contrast, do not make these predictions:
- Perspective-shift and SBI theories do not predict the differences observed in Experiment 2

- The ERH predicts, if anything, that two interveners should reduce verbal processing difficulty relative to one intervener (Expt 2)
- Word order theories do not predict that intervening dependents will increase processing difficulty in object-extracted RCs (Expt 1)
- We have corpus evidence that intervening dependents should sharpen syntactic expectations and therefore *facilitate* comprehension under expectation-based theories (Expts 1 & 2)

We conclude that locality is an important determinant of embedded-verb processing difficulty in Russian relative clauses.