Relative clause processing depends on who ‘they’ are

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38th Annual Conference of the German Linguistic Society (DGfS)
University of Konstanz, February 2016
Relevant Hebrew pronouns

\[\begin{align*}
\text{hem} &= \text{‘they’} \\
\text{pro} &= \text{‘they’} \\
\text{otam} &= \text{‘them’}
\end{align*}\]

- Related to the main goal of the study
- Must be considered, due to potential effects on processing
Difficulties with object relatives

Object relatives (i.e., *The horse that the rhino is catching __*) are hard to process, both for adults and children.

(Arnon, 2010; Arosio et al., 2012; Brandt et al., 2009; Friedmann et al., 2009; Gordon et al., 2001; Grodner & Gibson, 2005; Just & Carpenter, 1992; Kidd et al., 2007; King & Just, 1991, among others)
Difficulties with object relatives

Two approaches that explain difficulties with object relatives (OR):

1. **Cue-based retrieval processing**
   Lewis & Vasishth, 2005; Lewis et al., 2006; Van Dyke & McElree, 2006; 2011

2. **Featural intervention locality**
   Belletti et al., 2012; Friedmann et al., 2009; Grillo, 2008; Rizzi, 2013
Difficulties with object relatives

[head noun] complementizer [embedded subject] verb __

The horse that the rhino is catching __

Cue-based retrieval and featural intervention locality:

- ORs are hard when the head noun and the embedded subject are “similar”.
- OR processing is easier if these two constituents are dissimilar, i.e., if they bear different cues / features.
- Different prediction regarding which type of cues/features are relevant: any kind of cue (CBR) or only grammatical features that function as movement attractors (FIL).
Object relatives with an embedded pronoun

The horse that it is catching __

Both approaches predict ORs with an embedded pronoun to be easier than ORs with two full DPs (The horse that the rhino is catching __).

The head noun (full DP) and the embedded subject (pronoun, not a full DP) are sufficiently dissimilar.

Prediction is supported by experimental findings. (Arnon, 2010; Brandt et al., 2009; Friedmann et al., 2009; Gordon et al., 2001; Lassotta et al., 2015; Warren & Gibson, 2002)
Object relatives with an embedded arbitrary *pro*

Tare li et ha-sus she- mesarkim oto __
show me ACC the-horse that- *pro-* comb.3rd.pl.msc. him

Literally: ‘Show me the horse that (they) are combing’
Meaning: ‘Show me the horse that *someone* is combing’
Object relatives with an embedded arbitrary *pro*

- **Comprehension:** (Friedmann et al., 2009)

**ORs with two full DPs**
The horse that the cat is combing __

**70% accuracy**

**ORs with arbitrary *pro***
Ha-sus she- mesarkim oto __
The-horse that-*pro*-comb him

**90% accuracy**

- **Similar results in production.**
(Aron, 2010; Friedmann et al., 2009 Exp. 6; Guenzberg-Kerbel Shvimer & Friedmann, 2008; Novogrodsky & Friedmann, 2006)
Object relatives with an embedded arbitrary *pro*

Why are ORs with *pro* easier to process?

1. The head noun (*the horse*) is a full DP, but *pro* is not.

2. The head noun is singular, but *pro* is plural – facilitation of Number mismatch (Adani et al., 2010; 2014).

3. *pro* is a non-referential pronoun (Shlonsky 2014) – no retrieval of a specific discourse referent is required, hence processing is less costly.
Object relatives with an embedded arbitrary *pro*

- *pro* is a non-referential pronoun – hence, its processing is less costly.

- Referential properties of (1st- and 3rd-person) pronouns affect processing of ORs. (Haendler et al., 2015; Warren & Gibson, 2002)

- Processing is affected by the level of difficulty with which a referent is retrieved from discourse – but only in ORs! (integration cost metric – Warren & Gibson, 2002)
The present study
The present study

**Goal:** Find out whether referential properties of pronouns – specifically of *pro* – influence processing of Hebrew ORs.

**Exclusion of the other possibilities:**

- That *pro* facilitates processing because it is a pronoun (not a full DP).

- That facilitation is due to mismatch in Number (or any other cue/feature).
### Hem vs pro

<table>
<thead>
<tr>
<th></th>
<th><strong>hem ‘they’</strong></th>
<th><strong>pro ‘they’</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grammatical category</strong></td>
<td>pronoun</td>
<td>pronoun</td>
</tr>
<tr>
<td><strong>Person</strong></td>
<td>3rd</td>
<td>3rd</td>
</tr>
<tr>
<td><strong>Number</strong></td>
<td>plural</td>
<td>plural</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>masculine</td>
<td>masculine</td>
</tr>
<tr>
<td><strong>Pronunciation</strong></td>
<td>pronounced</td>
<td>unpronounced</td>
</tr>
<tr>
<td><strong>Referential</strong></td>
<td>Yes (specific discourse referent)</td>
<td>No (no specific discourse referent)</td>
</tr>
<tr>
<td><strong>Cognitive demand due to referential properties</strong></td>
<td>greater</td>
<td>smaller</td>
</tr>
</tbody>
</table>
**Hem vs pro**

### Specific discourse referent

**hem**

1. Yesh baxuc anashim}_{i} There (are) outside people
   
   ‘There are people outside.’

2. Hem}_{i} dof kim b-a-delet They knock at-the-door
   
   ‘They are knocking at the door.’

### No specific discourse referent

**pro**

1. Dof kim b-a-delet pro knock at-the-door
   
   ‘Someone is knocking at the door’
OR with *hem*

... **ha-susim**... the-horses

... **hem** tofsim?... they catch?

**Referential** *(more costly)*

- Full DP
- 3rd-person
- Masculine
- Plural

OR with *pro*

... **ha-susim**... the-horses

... **pro** tofsim otam?... catch them?

**Non-referential** *(less costly)*

- Full DP
- 3rd-person
- Masculine
- Plural
Testing the referential properties of *hem* and *pro*

- Presentation of sentences without a preceding **linguistic context**, “out of the blue” – problematic for *hem*, not for *pro*.

- All cues/features are controlled → different processing of ORs with *hem* and *pro* would imply that the effects are due to the pronouns’ referential properties.

- A referent presented **visually** should not be sufficient for *hem*. 
The resumptive pronoun *otam*

**OR with *hem***

*Ha-susim she-hem tofsim*
the-horses that-they catch

**OR with *pro***

*Ha-susim\(_i\) she- tofsim *otam\(_i\)_
the-horses\(_i\) that-*pro*-catch *them\(_i\)*

- *otam* is a resumptive pronoun (referring to the head noun, *the horses*) – obligatory in ORs with *pro*, but unacceptable in ORs with *hem*. 
The resumptive pronoun *otam*

**OR with 2 full DPs**

*Ha-susim*<sup>i</sup> *she-ha-karnafim tofsim* *(otam)<sup>i</sup>* __

the-horses<sup>i</sup> that-the-rhinos catch *(them)<sup>i</sup>*

- *otam* is arguably optional in ORs with two full DPs.

- However, resumptive pronouns in ORs with two full DPs are not frequent in natural speech (Ariel, 1999);

and they make processing harder.

(Farby et al., 2010; Meltzer-Asscher et al., 2015; Friedmann et al., 2009 – Exp. 2 picture task)
The resumptive pronoun *otam*

**OR with *hem***

\[
\text{Ha-susim } \text{she-hem } \text{tofsim} \\
\text{the-horses} \text{that-they catch}
\]

**OR with *pro***

\[
\text{Ha-susim}_i \text{ she- } \text{tofsim } \text{otam}_i \_ \\
\text{the-horses}_i \text{that-pro-catch } \text{them}_i
\]

**OR with 2 full DPs**

\[
\text{Ha-susim}_i \text{ she-ha-karnafim } \text{tofsim}(\text{otam}_i) \_ \\
\text{the-horses}_i \text{that-the-rhinos } \text{catch } \text{them}_i
\]
The resumptive pronoun *otam*

If *otam* affects processing across-the-board:

**ORs with *otam*** should be harder to process than **ORs without *otam***

<table>
<thead>
<tr>
<th>2 full DPs</th>
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<tr>
<td><em>Ha-susim</em>$_i$ <em>she-ha-karnafim tofsim otam</em>$_i$&lt;br&gt;the-horses$_i$ that-the-rhinos$_i$ catch <em>them</em>$_i$</td>
<td><em>Ha-susim$_i$ she-ha-karnafim tofsim</em>&lt;br&gt;the-horses$_i$ that-the-rhinos$_i$ catch</td>
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Predictions

- ORs with *pro* are easier than ORs with *hem* $\rightarrow$ referential properties play a role.

- No difference between ORs with *pro* and *hem* $\rightarrow$ referential properties do not play a role.

- ORs with *hem* are easier than ORs with *pro* $\rightarrow$ *otam* makes processing hard across-the-board.
Method
Participants

Children
N = 30 (3;11-6;4, mean age = 5;1)

Adult controls (preliminary sample)
N = 21 (22-34, mean age = 28)
Ma ha-ceva shel ha-susim...
What (is) the-color of the-horses...

**OR with hem** (7 items)
... she-hem tofsim __?
... that-they catch

**OR with pro** (7 items)
... she- tofsim otam __?
... that-pro- catch them

**OR with 2 full DPs (with otam)** (4 items)
... she-ha-karnafim tofsim otam __?
... that-the-rhinos catch them

**OR with 2 full DPs (no otam)** (3 items)
... she-ha-karnafim tofsim __?
... that-the-rhinos catch
Ma ha-ceva shel ha-susim...
What (is) the-color of the-horses...

Subject relatives (8 items)
... she-tofsim et ha-karnafim?
... that-catch ACC the-rhinos

Non-relatives (8 items)
... im ha-perax?
... with the-flower
Analysis

Two measures:

1) Response accuracy = proportion of correct color naming.

2) Proportion of target looks = Target / Target + Middle + Distractor.

Target = referent (pair of animals) of the head noun of the relative clause.
Results
Adults (N=21)

Eye movements & accuracy

Y-axis = proportion of target looks
X-axis = Time (from onset of the complementizer *she* until end of post-sentence silence)

Error shade = 95% CI

... she ha-karnafim tofsim (otam)?
... she-tofsim otam?
... she-hem tofsim?

47%

100%

94%

98%
Children’s apparent difficulties with *pro*

- While piloting, children were consistently wrong on ORs with *pro* as well as with *hem*.

- Difficulties with *hem* correspond to adults’, but not difficulties with *pro*.

- Children often produce ORs with *pro*.
  (Arnon, 2010; Friedmann et al., 2009 Exp. 6; Guenzberg-Kerbel Shvimer & Friedmann, 2008; Novogrodsky & Friedmann, 2006)

- In the present context, children might disregard the unpronounced *pro* → possibly due to the similarity of cues/features of the constituents (plural, masculine etc.).
Children’s apparent difficulties with *pro*

- A preceding game was administered to enhance the awareness of *pro* as a possible subject pronoun.

- Three trials in different modalities (comprehension & production).

- No use of relative clauses.
Eye movements & accuracy

![Graph showing eye movements and accuracy for children (N=30). The Y-axis represents the proportion of target looks, ranging from 0.00 to 1.00. The X-axis represents time from the onset of the complementizer 'she' until the end of post-sentence silence, measured in milliseconds (ms), ranging from 3000 to 7000. The graph includes different OR types: 2DP-resumptive, 2DP+resumptive, pro, and hem. Error shade represents the 95% CI.]
Individual differences among children

Mean accuracy vs. Memory Score = average score on digit forward & backward span tests
Discussion
Topics to be discussed

- *otam*

- *hem & pro*

- Theoretical implications
The resumptive pronoun *otam*

- ORs with 2 full DPs: with *otam* harder to process than without *otam*, for both adults and children. (In line with: Ariel, 1999; Farby et al., 2010; Friedmann et al., 2009 Exp.2; Meltzer-Asscher et al., 2015)

- *otam* does not make OR processing hard across-the-board – ORs with *pro* (with *otam*) were *not* harder than ORs with *hem* (without *otam*).

- The resumptive pronoun only affects processing of ORs with 2 full DPs, but not with embedded pronouns.
Difficulties with ORs with *hem*

- *Hem* was not preceded by a context.
- Interpretation as SRs – both adults (50% of the times) and children (90%).

Processing difficulties due to:
- Referential properties of *hem* → mentioned “out of the blue”.
- No help from other cues/features → all constituents are 3rd-person, plural, masculine etc.
- Pronoun’s referent is taken to be the only one mentioned – *the horses* – although this option is ungrammatical in Hebrew!
ORs with *hem* – what adults think

- The sentences are confusing; perceived as ambiguous.

- One participant initially asked always what was the previous question – she thought that *hem* referred to a couple of animals mentioned in the previous trial.
Difficulties with ORs with *pro*

- Only children found them hard.
- Children gave a SR interpretation in 70% of the cases.
- Response accuracy improved with higher memory score.

- If *otam = rhinos* :

  children either accept an “out of the blue” mention of a 3rd-person pronoun;

  or they take the visual context as sufficient to justify a 3rd-person pronoun usage.
Difficulties with ORs with *pro*

- **Discrepancy with previous studies:**
  - In previous studies: head noun was singular / *pro* is plural → easier
  - In the present study: head noun was plural / *pro* is plural → harder

- In the present study: similarity of all cues/features (Person, Number, Gender etc.) → additional difficulty.

- Previously attested facilitation is not due to the presence of *pro* per se (i.e., the fact that it is not a full DP).
<table>
<thead>
<tr>
<th>ORs with <em>hem</em></th>
<th>ORs with <em>pro</em></th>
</tr>
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<tbody>
<tr>
<td>Hard for both adults and children.</td>
<td>Hard only for children.</td>
</tr>
<tr>
<td>- Difficulties due to:</td>
<td>- Difficulties due to:</td>
</tr>
<tr>
<td>* referential properties.</td>
<td>* similar cues/features on constituents.</td>
</tr>
<tr>
<td>* similar cues/features on constituents.</td>
<td></td>
</tr>
<tr>
<td>- Performance does not improve with stronger memory skills.</td>
<td>- Performance improves with stronger memory skills.</td>
</tr>
<tr>
<td>- Hard.</td>
<td>- Hard, but still relatively easier.</td>
</tr>
</tbody>
</table>
Theoretical implications given the data

- Similar **cues/features** made processing hard:
  * Adults → difficulties with ORs with *hem*.
  * Children → difficulties with both pronoun conditions.

- **Lack of context** made ORs with *hem* harder than ORs with *pro*:
  * In adults, clearly.
  * In children, to some extent (memory skills related only to performance on ORs with *pro*).

- Effects of both **cues/features similarity** (CBR or FIL) and **pronouns’ referential properties**.
Theoretical implications given the data

- A theory of sentence processing needs to account for:

  * Structural / syntactic effects: e.g., intervention effects (featural intervention locality).

  * Interference effects from constituents marked with similar cues, overloading working memory (cue-based retrieval).

  * Discourse effects: e.g., pronouns’ referential properties, discourse accessibility.
Theoretical implications given the data

- **Integration cost metric** (Warren & Gibson, 2002) – processing difficulty increases as a function of two interacting factors:

  (1) long distance between the moved constituent and its gap position;
  (2) level of difficulty with which a referent is retrieved from discourse.

- This account explains only discourse effects in ORs (or otherwise complex structures).

- Need to account for discourse effects which are independent of syntactic structure – same discourse accessibility effects of pronouns in ORs and SRs (Haendler & Adani, in prep).
Processing mechanisms related to sentence-internal structure / characteristics (e.g., intervention effects, cue-based retrieval)

Discourse-related processing mechanisms, related to the presence and usage of a certain referring expression, but not to cues/features or syntactic structure.
Relative clause processing depends – also – on who **THEY** are
Many thanks to:
- Children and their parents; adult participants.
- Staff of the kindergartens *Gan Halom* (Malha, Jerusalem) & *Gan Rimon* and *Gan Dror* (Ramat Rahel).
- Reut Mirom, Sharon Armon-Lotem, Tom Fritzsche, Flavia Adani and the ALADDIN research group.

The research is supported by a scholarship from *Ernst Ludwig Ehrlich Studienwerk* (Grant PF123). Participation in the conference is supported also by *Potsdam Graduate School* (Grant D_422).