Pupillary responses to pronoun manipulations in Dutch

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Overview

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- Experimental Design
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Introduction

Children make mistakes in the interpretation of:

- *He washes him
- He washes himself

In Italian no such errors are made

Differences between Dutch/English and Italian?


Introduction

Italian: 2 types of subject pronouns
- Null subject (Ø)
- Overt subject

How much information does a subject hold?
- How much ‘freedom’ is there when solving a pronoun?
What are the effects of the presence and interpretation of subject pronouns on the processing and interpretation of object pronouns?
Experimental Design

Eye-tracking study looking at pupil size

- 40 Dutch adults
- 120 Stories, audio
- 2 Pictures
- Referent selection task

Conditions

- Pronoun vs. full NP as the **subject**
- Pronoun vs. reflexive as the **object**
Experimental Design

Stories of 3 phrases
1 De egel heeft een boomhut gebouwd.
2 Afgelopen dinsdag liep de egel met de muis door het bos naar huis,
3 - terwijl hij/de egel hem volgde over een donker pad.
   - terwijl hij/de egel zich haastte over een donker pad.

Afterwards, a question was asked about one of the characters
Experimental Design
Hypotheses

1. A subject NP is easier to process than ‘hij’
2. The object ‘zich’ is easier to process than ‘hem’

3. An object pronoun is more difficult to resolve when following a subject pronoun than when following a subject NP, i.e. The ambiguity of the subject plays a role in the processing of the object
Results

![Graph showing relative dilation over time with different categories: hij/hem, NP/hem, hij/zich, NP/zich. The x-axis represents time in milliseconds (0-5000), and the y-axis represents relative dilation. The graph includes markers for onset and offset of subject, object, story, and question.]
Results

Linear mixed-effects models (lmer)
- Fixed effects and random effects (mixed effects)
- Useful with repeated measures
- Advantage in dealing with missing values (as opposed to repeated-measures ANOVA)
- Mixed-effects analysis is relatively easy to do and does not require a balanced design (which is generally necessary for repeated-measures ANOVA)

NB: t-values given. We assume $t > 2$ means there is an effect
Results

Testing the subject and object conditions at specific time points with an lmer:

At time after onset object == 2500, no differences between conditions (t = 1.26 subject, t = 1.03 object)

At time after onset object == 4500: t = 0.20 subject, t = 3.90* object
-> ’hem’ more difficult than ‘zich’
Results

![Graph showing relative dilation over time]

- Red line: hij/hem
- Blue line: NP/hem
- Green line: hij/zich
- Orange line: NP/zich

- X-axis: Time (in ms)
- Y-axis: Relative Dilation

Key points:
- Onset object
- Onset subject
- Offset story
- Onset question
- Offset question

Graph illustrates the relative dilation over time for different conditions (hij/hem, NP/hem, hij/zich, NP/zich).
Results

1000ms after the start of the question:

No difference between question types (t = 0.78)
Difference between objects (t = 2.45)
No difference between subjects (t = 0.28)
Results

Accuracy:
- NP easier than ‘hij’ ($p < 0.001$)
- ‘zich’ easier than ‘hem’ when the question refers to the subject ($p = 0.002$)

RT:
- Questions referring to the subject are answered faster ($t = -3.49$)
- Questions with an NP are answered faster ($t = -4.24$)
- ‘zich’ faster than ‘hem’ when the question refers to the subject ($t = -2.00$)
Results

Summary so far:

1. A subject NP is easier to process than ‘hij’
   - found in RT and ACC but not DIL
2. The object ‘zich’ is easier to process than ‘hem’
   - partially found in RT, ACC and DIL
3. An object pronoun is more difficult to resolve when following a subject pronoun than when following a subject NP
   - GAMs
Results

Generalized additive models (GAMs)
- the story examined over time
- linear predictor is specified in terms of a sum of non-parametric smooth functions of predictor variables
- Overfitting prevented by penalties on smoothing
- Can be used on eye-tracking data, EEG, fMRI

1 filter out the trend
2 fit the residuals for each condition
3 compare different models

Results

![Graph showing Relative Dilation over Time]

- **Relative Dilation**
- **Time**
- **Onset object**
- **Onset subject**
- **Offset story**
- **Onset question**
- **Offset question**

Legend:
- Red: hij/hem
- Blue: NP/hem
- Green: hij/zich
- Orange: NP/zich
Results
Results

Anova: Full model vs. model \textbf{without} the object condition

Full model is better \((p < 0.001)\)
Results

Anova: Full model vs. model **without** the subject condition

Full model is better \((p < 0.001)\)
Results

Interactions between all conditions found ($p = 0.01$), so the results were not just additive.

This is important to be able to say something about the influence of one condition on the other.
Results summary

1. A subject NP is easier to process than ‘hij’
   -> found in RT, ACC and GAMs, but not DIL

2. The object ‘zich’ is easier to process than ‘hem’
   -> partially found in RT, ACC and DIL, found in GAMs

3. An object pronoun is more difficult to resolve when following a subject pronoun than when following a subject NP
   -> interaction found in GAMs
Conclusions

More ambiguous/free pronouns are more difficult to process ('hem' vs. 'zich', 'hij' vs. NP)

Ambiguity of the subject influences processing of the object