What causes the processing advantage in the comprehension of German object relative clauses?

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COMPREHENSION OF OBJECT RELATIVE CLAUSES

Healthy adults	Individuals with aphasia (IWAs)
Offline performance: • At ceiling [1] • Morphological features play an important role in sentence comprehension [1]	**Offline performance:** • Within chance range (in sentence-picture verification tasks) [1] • Difficulties in the interpretation of morphological case and number features • **But** better preserved comprehension of case-marked than of number-marked sentences [1,4]
Online processing: • Processing advantage: Case marking > number marking (i.e., sentences disambiguated by subject-verb agreement) [2,3]	**No online processing data available yet**

AIMS OF THE STUDY

Provide online (visual-world paradigm) and offline data in aphasia

➢ **What causes the processing advantage for case marking over number marking?**

1. Functional differences between morphological features
   ⇨ Prediction: Case ≠ Number
   OR
2. Differences in point of disambiguation
   ⇨ Prediction: Immediate > Early > Late disambiguation

PARTICIPANTS

Individuals with aphasia

ID	Age (yrs)	Sex	Time post-onset (yrs)	Aphasic syndrome, severity[5]
Po1	62	M	20	Broca, moderate
Po2	46	F	2	Broca, moderate
Po3	70	M	2	Broca, moderate
Po4	60	M	2	Broca, moderate
Po5	49	F	20	Broca, mild
Po6	43	F	15	Anomic, mild
Po7	51	M	14	Anomic, mild
Po8	61	M	12	Anomic, mild
Po9	64	M	4	Anomic, mild
P10	75	M	2	Wernicke, mild

➢ Age: Mean=58.1 yrs, range=43–75 yrs
➢ Comprehension:
• Single words and semantically irreversible sentences [6,7] ✓
• Semantically reversible non-canonical sentences [7] ✗

Healthy adults

➢ 35 participants (19 female, Age: Mean=58.4 yrs, range=38–75 yrs)

MATERIAL – METHOD – ANALYSIS

Sentences

➢ n=48 target sentences: Interrogative object relative clauses (ORCs), 3 conditions, 16 items per condition:

Feature	Disambiguation point	Example
Case	**Immediate: Relative pronoun**	Wo ist der Hamster, **den** gerade der Frosch wäscht? *Where is the hamster that the frog is currently washing?*
Case	**Early: Embedded subject**	Wo ist die Ente, die gerade **der Fisch** wäscht? *Where is the duck that the fish is currently washing?*
Number	**Late: Verb**	Wo ist das Kamel, das gerade die Vögel **waschen**? *Where is the camel that the birds are currently washing?*

➢ n=48 filler sentences: Subject relative clauses with immediate, early, or late disambiguation

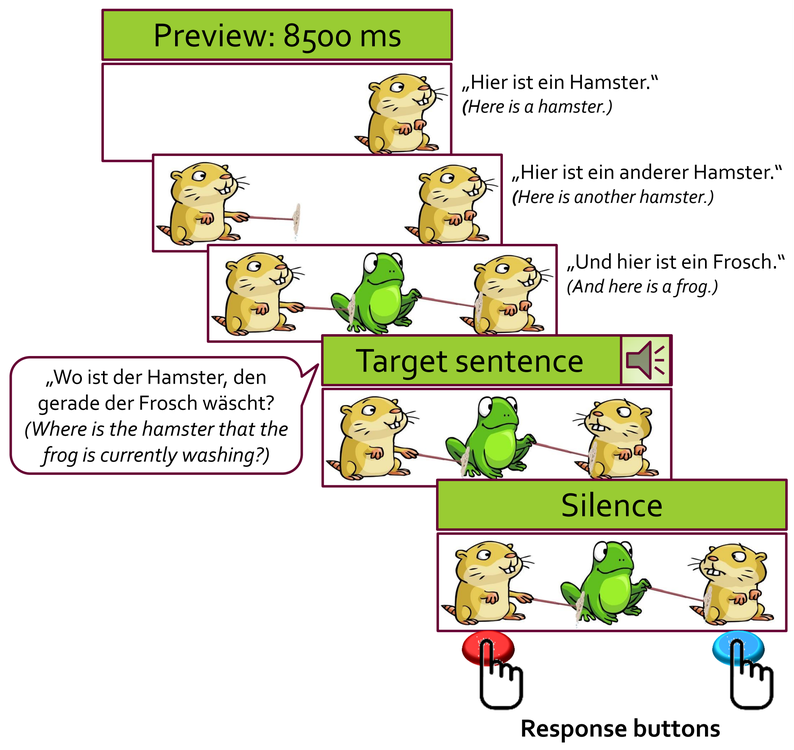
Data analysis

➢ **Offline:** Accuracy in referent identification task
➢ **Online:** Eye movements (proportion of looks to target)
• Regions of interest:

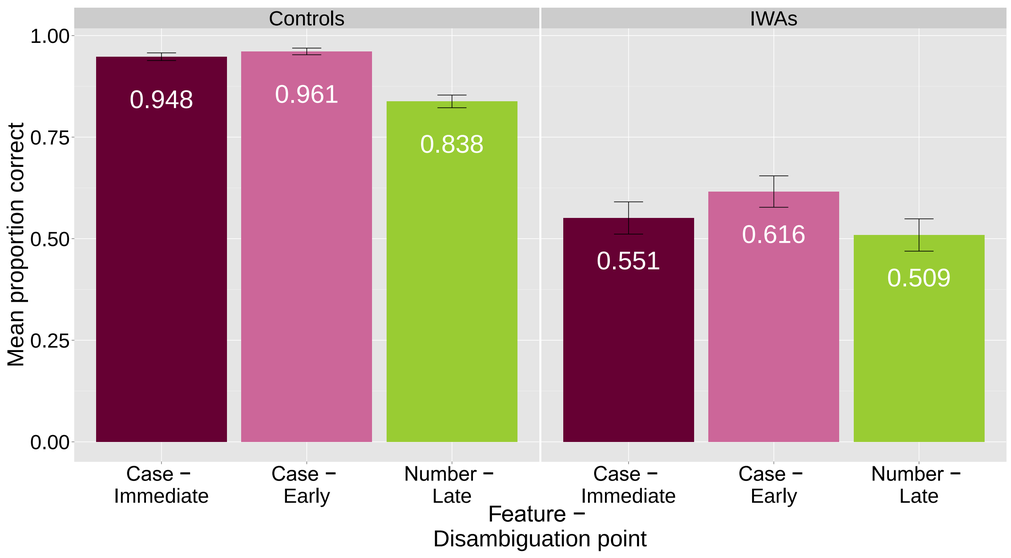
Baseline	Matrix clause	Relative clause	Silence
2000 ms before sentence onset	*Wo ist der Hamster*	*den gerade der Frosch wäscht?*	2000 ms after sentence offset

Visual-world paradigm

➢ Eye tracking with referent identification task[8]



RESULTS - ACCURACY



Binary Logistic Regression[9]

➢ Main effect of group:
Controls > IWAs (z=-6.89, *p*<.001)

Group	Case: Immediate vs. Early	Case vs. Number
Controls	= (z=0.98, *p*>.05)	> (z=-7.71, *p*<.001)
IWAs	= (z=1.24, *p*>.05)	= (z=-1.60, p>.05)

IWAs – SINGLE CASE ANALYSIS			
	% correct | Chance level performance		
	Case		Number
ID	Immediate	Early	Late
Po1	75 | >	63 | =	63 | =
Po2	50 | =	88 | >	69 | =
Po3	50 | =	56 | =	56 | =
Po4	56 | =	75 | >	44 | =
Po5	88 | >	81 | >	69 | =
Po6	81 | >	75 | >	50 | =
Po7	25 | <	44 | =	31 | =
Po8	38 | =	31 | =	19 | <
Po9	25 | <	56 | =	56 | =
P10	64 | =	47 | =	53 | =
GROUP	55 | =	62 | >	51 | =

NOTE: = not significantly different from chance; < significantly below chance; > significantly above chance

DISCUSSION

Controls:

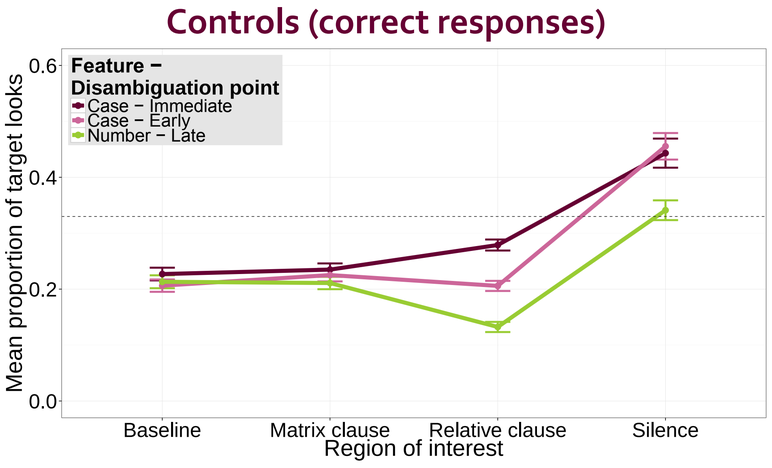
➢ **Accuracy:**
• Better comprehension of case-marked than of number-marked ORCs[1]
• Impact of morphological features instead of disambiguation point
➢ **Eye movements:**
• Incremental use of morphological features ⇨ Increase in target looks tied to disambiguation point

IWAs:

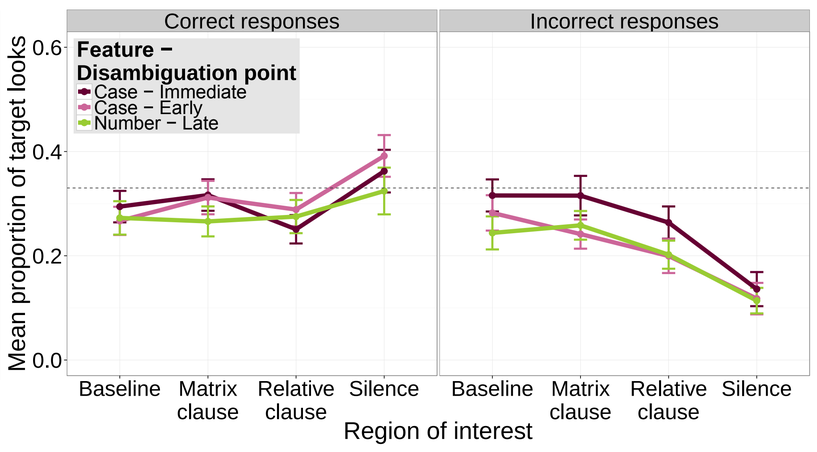
➢ **Accuracy:**
• No comprehension advantage for case- or number-marked ORCs ⇨ Equally impaired comprehension
• Heterogeneous performance pattern across IWAs
➢ **Eye movements:**
• No processing advantage for any morphological feature or disambiguation point
• Incorrect responses: Misinterpretation of morphological features after sentence offset[10]

RESULTS – EYE MOVEMENTS

Controls (correct responses)



IWAs



Linear Mixed Models

➢ **Case: Immediate > Early** from Region 2 to 3 (β=-0.03, *p*<.01), **Immediate < Early** from Region 3 to 4 (β=0.05, *p*<.001)
➢ **Case > Number** from Region 2 to 3 (β=-0.03, *p*<.001)
➢ **Case: Immediate = Early** for all regions (sliding contrast coding) (*p*>.05)
➢ **Case = Number** for all regions (*p*>.05)
➢ **Effect of accuracy: Correct > incorrect responses** from Region 3 to 4 (β=-0.19, *p*<.001)

Error bars =M±SE.

CONCLUSION

Functional difference or point of disambiguation – what causes the processing advantage?

Healthy adults' comprehension of ORCs benefits from case marking. The online data reveal that the processing advantage is caused by an earlier disambiguation point for case marking, rather than by functional differences between case and number features.
In **IWAs**, neither functional differences between features nor different disambiguation points result in a processing advantage.

References: [1] Burchert et al. (2003). *Brain and Language*. [2] Meng, & Bader (2000). *Language and Speech*. [3] Friederici et al. (1998). *Biological Psychology*. [4] Bates et al. (1987). *Brain and Language*. [5] Huber et al. (1983). *Aachener Aphasie Test*. [6] Stadie et al. (2013). *LEMO 2.0*. [7] Burchert et al. (2011). *Sätze verstehen*. [8] Adani, & Fritzsche (2015). *Proceedings of the 39th Annual Boston University Conference on Language Development*. [9] Jaeger (2008). *Journal of Memory and Language*. [10] Hanne et al. (2015). *Journal of Neurolinguistics*.

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