

On-line Processing of German Number-marked Relative Clauses in the Visual-world Paradigm

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Processing of relative clauses

- Subject-object asymmetry: Subject relative clauses (SRC) are easier to process than object relative clauses (ORC)

Healthy adults		Individuals with aphasia (IWAs)	
SRC = ORC ^[1]	SRC > ORC ^[2]	SRC > ORC ^[1]	SRC > ORC ^[3]
Off-line	On-line	Off-line	On-line

Processing of number agreement:

Healthy adults	Individuals with aphasia (IWAs)
<ul style="list-style-type: none"> Number agreement important in RC processing^[1] 	<ul style="list-style-type: none"> Number agreement impaired in all syndromes^[4] No benefit from unambiguous compared to ambiguous number agreement^[1]

Off-line

Experimental design

Sentences:

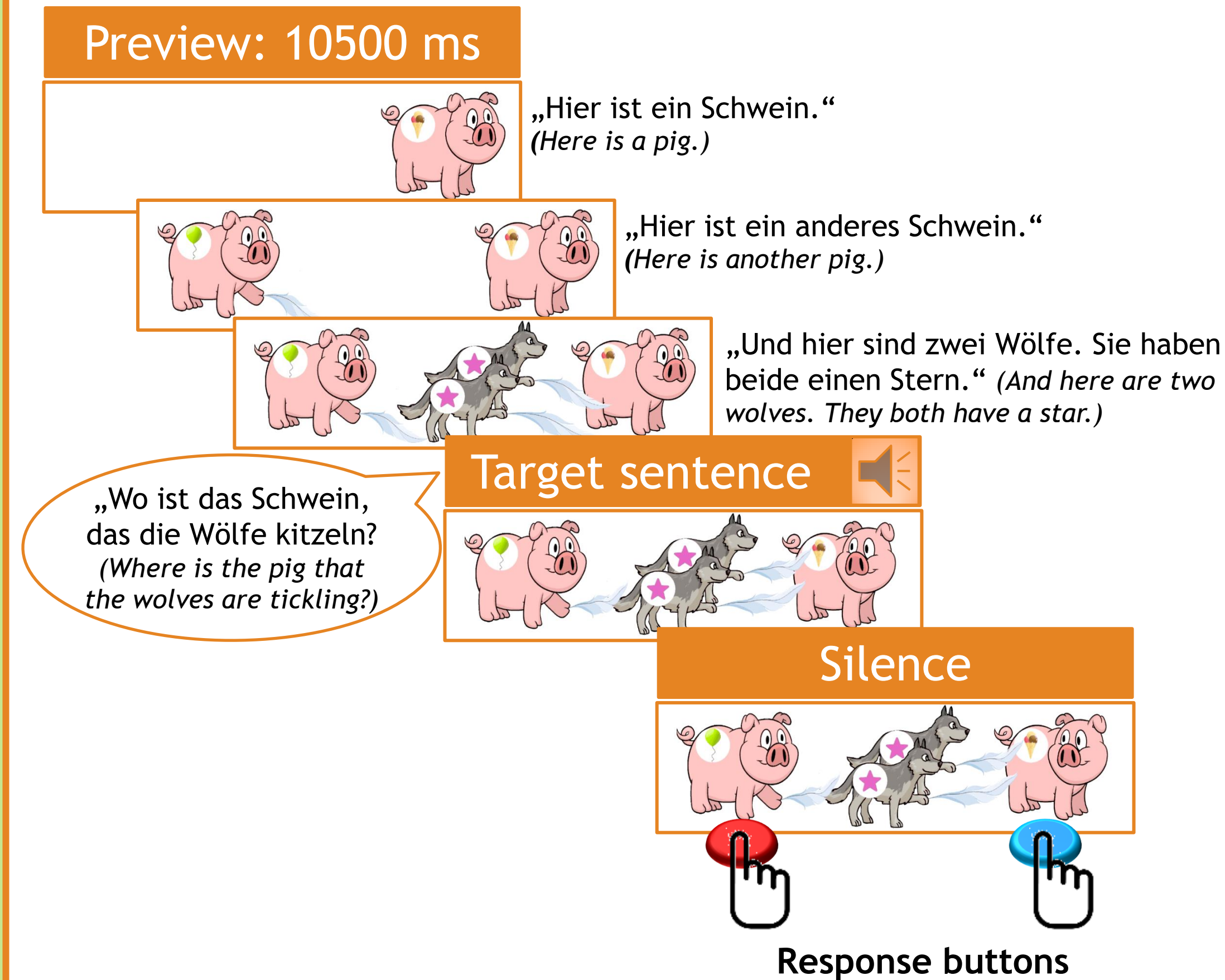
- n=32 target sentences: Interrogative RCs, 2 conditions, 16 items per condition:

n=32 interrogative RCs	
n=16 SRC	n=16 ORC
Wo ist das Schwein, das die Wölfe <u>kitzelt</u> ? (Where is the pig that is tickling the wolves?)	Wo ist das Schwein, das die Wölfe <u>kitzeln</u> ? (Where is the pig that the wolves are tickling?)

- n=32 fillers: Questions referring to symbol which identifies one of the animals (e.g., Where is the pig with the balloon?)

Visual-world paradigm:

- Eye tracking with referent identification task^[5]



Analysis:

- Off-line: Accuracy in referent identification task
- On-line: Eye movements
 - Regions of interest:

Preview	Target sentence			RC type	Silence
	Matrix clause	Relative clause	Verb		
Hier ist ein Schwein. Hier ist ein anderes Schwein. Und hier sind zwei Wölfe. Sie haben beide einen Stern.	Wo ist das Schwein	das die Wölfe	kitzelt?	SRC	divided into bins of 500 ms
			kitzeln?	ORC	

- Areas of interest: Target and distractor animals

Off-line results

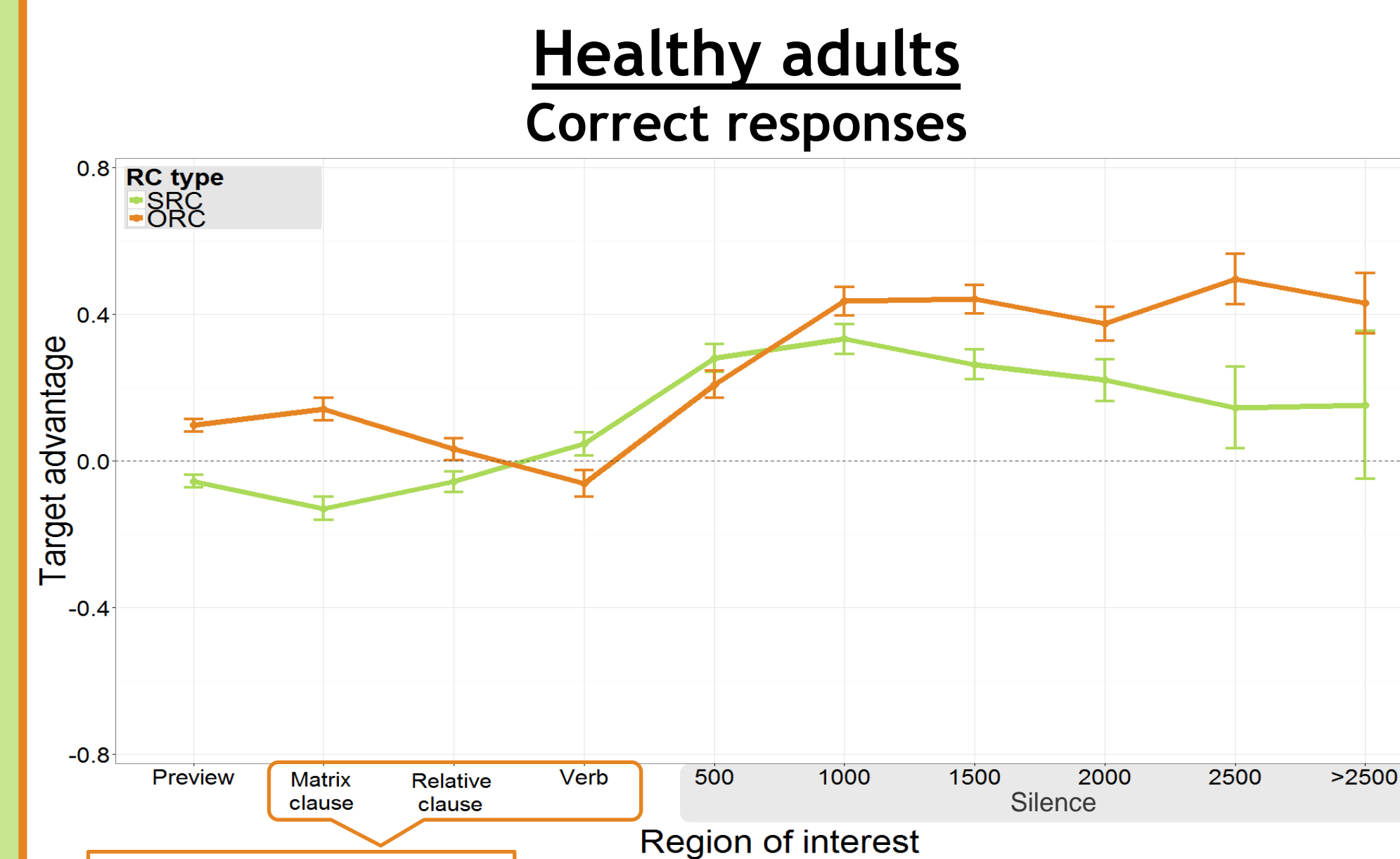
Group	% correct		Subject-object asymmetry (Binary logistic regression ^[6])	Chance performance*	
	SRC	ORC		SRC	ORC
IWAs	75	41	$p < .001$	>	=
Healthy adults	99	93	$p < .05$	>	>

- Main effect of group: Healthy adults > IWAs ($p < .001$, Binary logistic regression^[6])

* = within chance; < significantly below chance; > significantly above chance (Binomial test, two-sided)

ID	% correct		Subject-object asymmetry (Binary logistic regression ^[6])	Chance performance*	
	SRC	ORC		SRC	ORC
P01	81	87	n.s.	>	>
P02	56	50	n.s.	=	=
P03	63	38	n.s.	=	=
P04	88	13	$p < .01$	>	<
P05	88	19	$p < .001$	>	<

On-line results

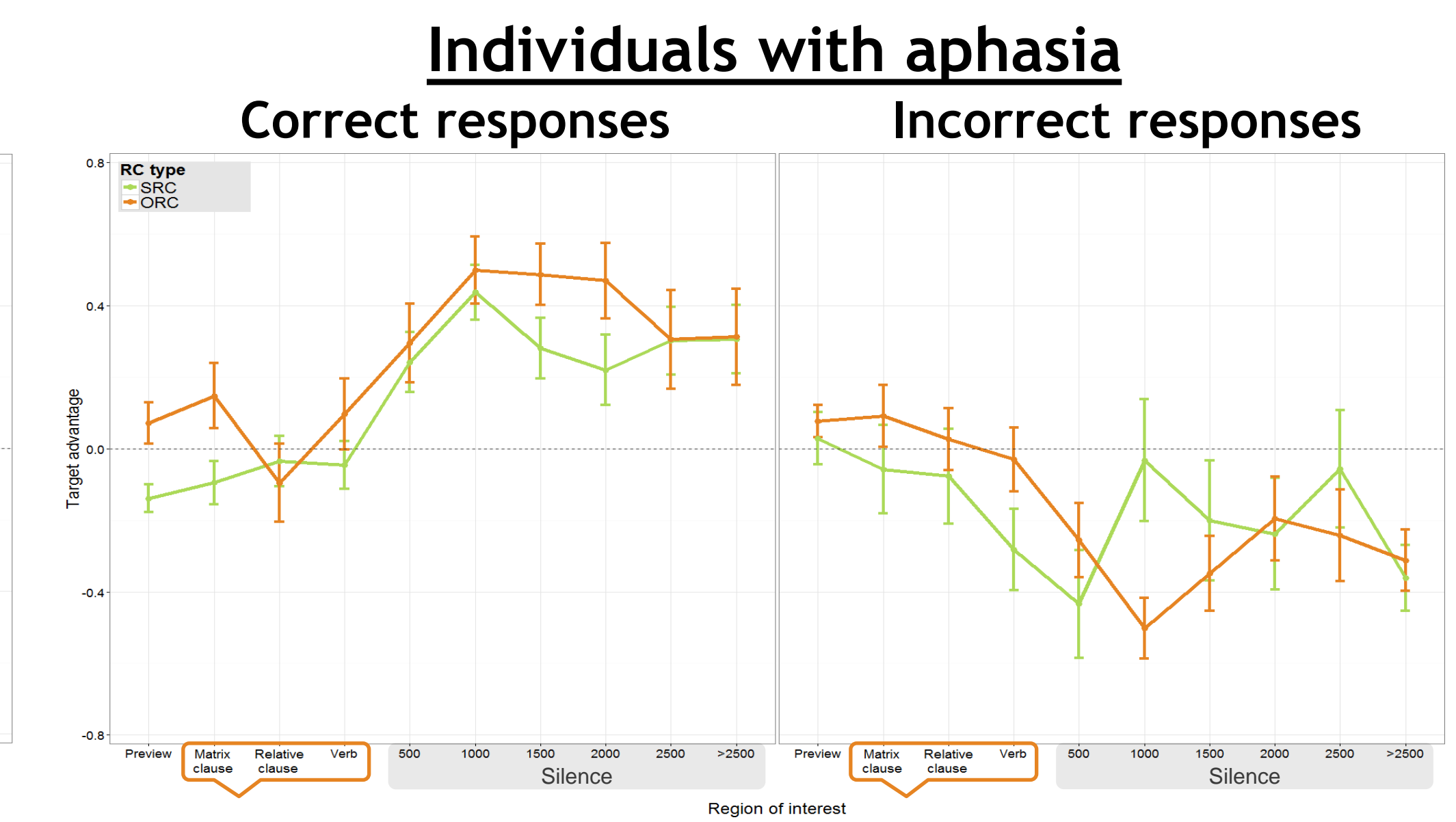


„Wo ist das Schwein, das die Wölfe kitzeln?“

Linear Mixed Model

- Regions Preview, Matrix clause, Relative clause:
 - SRC < ORC (estimate=0.15, SE=0.24, $t=-6.478$; estimate=0.27, SE=0.04, $t=6.251$; estimate=0.09, SE=0.04, $t=2.211$)
- Region Verb:
 - SRC > ORC (estimate=-0.11, SE=0.05, $t=-2.306$)
- Regions 1500, 2000, 2500:
 - SRC < ORC (estimate=0.18, SE=0.06, $t=3.188$; estimate=0.15, SE=0.07, $t=2.133$; estimate=0.34, SE=0.12, $t=2.784$)

Plots show target advantage (= proportion of looks to target - proportion of looks to distractor) during Preview, Matrix clause, Relative clause, Verb, Silence after RC offset (bins of 500 ms). If positive, participants are looking at the target more than the distractor animal; if negative, they are looking at the distractor more than the target animal. Error bars = M ± SE.



Linear Mixed Model

Main effect of accuracy: correct > incorrect (estimate=0.36, SE=0.03, $t=10.795$)

Correct responses: patients = healthy adults in all regions (all $-1.580 < t < 1.821$)

Correct responses	Incorrect responses
Regions Preview, Matrix clause: <ul style="list-style-type: none"> SRC < ORC (estimate=0.21, SE=0.07, $t=-3.118$; estimate=0.24, SE=0.10, $t=2.34$) 	Region 1000: <ul style="list-style-type: none"> SRC > ORC (estimate=-0.46, SE=0.17, $t=-2.715$)

Aims of the study: Visual-world paradigm and off-line data

- Is there a subject-object asymmetry in the on- and off-line processing of German number-marked relative clauses in healthy adults and IWAs?
- What do eye movements reveal about the IWAs' use of number agreement in the interpretation of RCs?

Participants

Individuals with aphasia

ID	Age	Sex	Years post-onset	Etiology, location	Aphasic syndrome, severity
P01	42	F	15	Ischemic, A. cerebri left	Anomic, mild
P02	51	M	14	Ischemic, A. cerebri left	Anomic, mild
P03	61	M	12	Ischemic, A. cerebri left	Anomic, mild
P04	46	F	2	Ischemic, A. cerebri left	Broca, moderate
P05	74	M	18	Ischemic, A. cerebri left	Broca, moderate

- Age: mean=54.8 years, range=42-74 years
- Comprehension:
 - Single words ✓
 - Semantically irreversible sentences ✓
 - Semantically reversible non-canonical sentences ✗

Healthy adults

- 11 participants (1 male, age: mean=58.9 years, range=48-75 years)

References:

[1] Burchert et al. (2003). *Brain and Language*. [2] Bader & Meng (1999). *Journal of Psycholinguistic Research*. [3] Caplan et al. (2007). *Brain and Language*. [4] Bates et al. (1987). *Brain and Language*. [5] Adani & Fritzsche (2014). On the relation between implicit and explicit measures of child language development: Evidence from relative clause processing in 4-year-olds, Talk to be presented at the Boston University Conference on Language Development. [6] Jaeger (2008). *Journal of Memory and Language*. [7] Hanne et al. (2011). *Aphasiology*.

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Interpretation

Subject-object asymmetry:

Healthy adults		Individuals with aphasia	
SRC > ORC	SRC > ORC	SRC > ORC	SRC = ORC
Off-line	On-line	Off-line	On-line

- IWAs: Heterogeneous performance patterns
- Healthy adults and IWAs: Initial preference for distractor animal (= theme) has to be overcome in SRC

Preliminary conclusion

- Healthy adults show subject-object asymmetry (off-line) and use number agreement (on-line)
- IWAs show subject-object asymmetry (off-line) and use number agreement (on-line), but with varying success (i.e. only correct responses)

Processing of number agreement:

- Healthy adults:
 - Increase in target advantage at verb and subsequent silence region: Use of number agreement
- Individuals with aphasia:
 - Varying eye movement patterns depending on accuracy^[7]
 - Correct responses:
 - No difference in eye movements compared to healthy adults
 - Increase in target advantage at verb and subsequent silence region: Use of number agreement
 - Incorrect responses: Erroneous processing of number agreement