Neural correlates of referential processing: Event-related potentials for ambiguity versus resolution

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Introduction

- Successful language comprehension involves establishing reference
- Referential ambiguities (1a) have most commonly been shown to elicit a sustained negativity (**Nref effect**) relative to controls (1b) [1-3]

  1a. *David shot at John as he…* 1b. *David shot at Linda as he…*
- Greater ambiguity due to contextual bias (as measured by offline referential Cloze task) is associated with larger amplitude Nref effects [4]
- Previous work has also found substantial individual differences in ERP responses to referential ambiguity, with some participants showing a late positive component (**LPC effect**) instead of Nref effects [5-6]
- ERP effects of ambiguity can persist for 1 second or more beyond the point of disambiguation [3], and to date no ERP marker of successful reference resolution has been reported (but see [7])

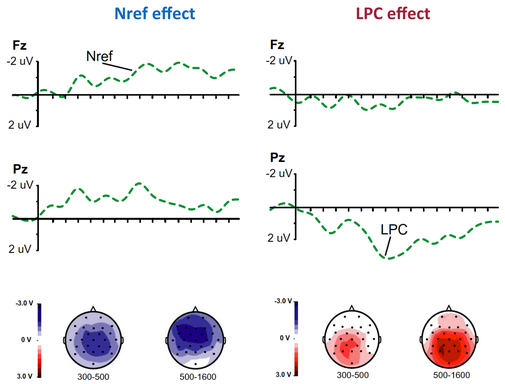

Figure modified from [3]. *Top*: Difference waves (ambiguity–control) for participants that show Nref effects (left) versus LPC effects (right); *Bottom*: Corresponding scalp distributions within indicated time windows.

Research Questions

- Do Nref and LPC effects in such contexts simply index referential ambiguity, or are they sensitive to the *degree* of ambiguity (i.e., to referential entropy)?

  3ref > 2ref > 1ref
- Can we detect an ERP correlate for successful reference resolution?

References

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Methods

Participants

- 30 right-handed native German speakers (24 female)
- Mean age: 24.0 (range 19 to 31)

Design

- Each experimental item paired a question (Figure 1, top) with three visual displays (1ref, 2ref, 3ref) which manipulated referential entropy
- Filler conditions (F1, F2, F3) paired a different question (Figure 1, bottom) with the same displays to ensure a 50% likelihood that either object type (e.g., ball or ovenmitt) would be the target on any given trial
- 120 trials in total
- 6 counterbalanced lists (Latin Square design)

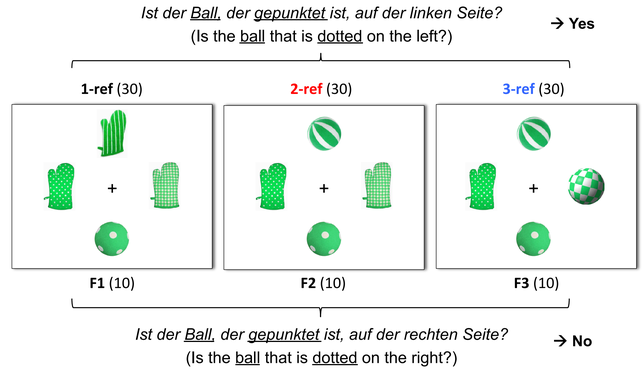


Figure 1. Example Stimulus. Experimental question (top) and Filler question (bottom). Target words underlined.

Trial Procedure

- Participants previewed displays (self-paced, min 3000 ms)
- Participants then maintained fixation while a Yes/No question was presented visually, word by word, in center of screen (SOA: 500 ms, ISI: 100 ms)
- Objects remained visible peripherally during trial to minimize working memory load
- Feedback was given after each response (Correct, Incorrect)

EEG Recording and Analysis

- 26-channel actiCAP, BrainAmps DC amplifier (Brain Products)
- Bandpass filter: 0.03-40 Hz
- Re-referenced to average mastoids
- ERPs analyzed separately at onset of noun (e.g., *ball*) and disambiguation (e.g., *dotted*) within 500-1000 ms window

Results and Discussion

Behavioral Results

Participants were highly accurate resolving the correct referent (*M* = 0.98)

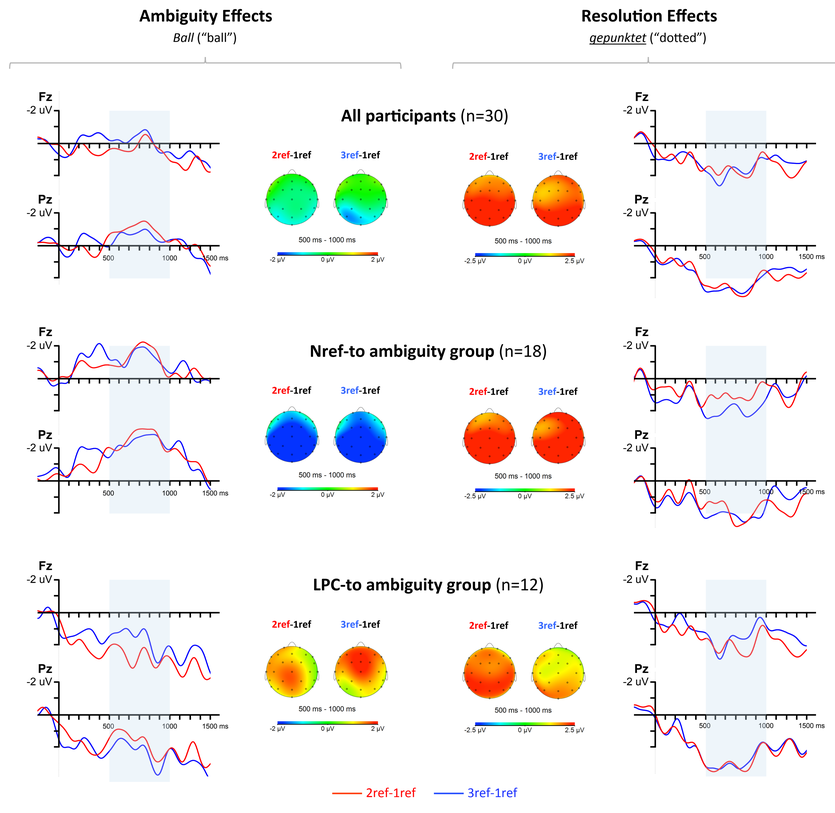
Accuracy					
1-ref	2-ref	3-ref	f1	f2	f3
0.99	0.98	0.98	0.99	0.95	0.99

Individual Differences in ERP Response

- Consistent with [5], examination of single-subject ERP effects revealed individual differences in whether ambiguous anaphors elicited an Nref effect or LPC effect relative to unambiguous controls
- Participants were divided into two groups based on the sign of mean difference between ambiguity and control at posterior channels (500-1600 ms) for each subject

Statistical Results

		Ambiguity Effects		Resolution Effects	
		Cond	Cond x AP	Cond	Cond x AP
All	2-1	n.s.	.048 *	.000 ***	.085 ·
	3-1	n.s.	.003 **	.000 ***	.053 ·
	3-2	n.s.	.068 ·	n.s.	n.s.
Nref group	2-1	.008**	.011 *	.000 ***	n.s.
	3-1	.002**	.018 *	.003 **	.064 ·
	3-2	n.s.	n.s.	n.s.	n.s.
LPC group	2-1	.003**	n.s.	.004 **	n.s.
	3-1	.002**	n.s.	.062 ·	n.s.
	3-2	n.s.	.058 ·	n.s.	n.s.



Ambiguity Effects

- Regardless of which ambiguity effect was elicited, both 2ref and 3ref conditions elicited an ambiguity response relative to controls
- However, the magnitude of these effects did not reliably differ between 2ref and 3ref conditions
- This pattern of results suggests that electrophysio-logical responses to referential ambiguity—whether Nref or LPC—are not sensitive to the degree of ambiguity per se, but instead index ambiguity itself

Resolution Effects

- Disambiguation was associated with similar magnitude, widely distributed positivities for both ambiguous conditions relative to control
- This finding is consistent with previous work showing P600 effects for updating the mental representation of what is being communicated [8-9]

Conclusions

- These results help inform our under-standing of referential processing and serve to constrain future computational models of such processing

Next Steps

- We are currently running linguistic version

Figure 2. ERP Results. Difference waves (filtered for presentation purpose only: 5 Hz high cut-off, 48 dB/ oct) and corresponding scalp distributions within 500-1000 ms time window.

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