Visual context effects on incremental question processing – ERP evidence from German quantifier restriction

- AMLaP 2015 -

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0. Overview

Questions

- Does non-linguistic information incrementally constrain compositional-semantic interpretation?
- Is there evidence for semantic reanalysis effects during online sentence comprehension?
- What are the neurophysiological correlates of compositional-semantic processing difficulties?

0. Overview

1. Background
2. ERP studies on quantifier restriction
3. Summary

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1. **Background**
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1. Background

Quantifier restriction

(1) All cabs are yellow.

1. Background

Quantifier restriction

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1. Background

Quantifier restriction

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Quantifier restriction

(1) All cabs are yellow.

1. Background

Quantifier restriction

- Quantifiers like *all*, *every*, *some*, *many*, *most*: grammatical determiners expressing abstract quantity information (e.g. Barwise & Cooper, 1981)

- Specific property: quantifiers trigger **domain restriction** over the nominal arguments they modify (von Fintel, 1994; Stanley & Szabó, 2000; Westerstahl, 1985)

  → the quantifier *all* is automatically restricted to the set of a contextually relevant set of cabs rather than referring to all existing cabs in the world

1. Background

Context effects on semantic processing (1)

- The vast majority of existing ERP studies focuses on contextual effects on the **lexical integration of words**
- Context types:
  - **World knowledge** (Hagoort et al., 2004, Delong, Urbach & Kutas, 2005; Federmeier, 2007, van Berkum et al., 2005)
  - **Speaker identity** (Hagoort & van Berkum, 2007)
  - **Discourse** (Nieuwland & van Berkum, 2006; Filik & Leuthold, 2008; van Berkum et al., 2003,2005; Otten & van Berkum, 2007)
  - **Pragmatic processes** (Hunt et al., 2013; Noveck & Posada, 2003; Nieuwland et al, 2010; Politzer-Ahles et al., 2013)

1. Background

Context effects on semantic processing (2)

- N400 effects also on the semantic processing of verb action information in picture verification task (Knoeferle et al., 2011)
- Disourse effects on quantifier processing (bare numerals): late positivity (Kaan et al., 2007)
- Quantifier all in a picture-sentence verification task: inconsistent effects (Politzer-Ahles et al., 2013)

1. Background

Context effects on semantic processing: Summary

- Relatively stable effects in the domain of lexical-semantic integration (N400 effects)
- Late and/or small effects when there is no lexical expectation involved
- Up to now: no studies on quantifier restriction at a later sentential position („semantic reanalysis“ position)

1. Background

The current study

- Investigates contextual effects on compositional-semantic processing
- Provides further evidence for or against the incrementality of quantifier processing
- Focuses on **quantifier restriction** and potential **meaning shifts** (semantic revision)

The current studies

Semantic revision

(4) All cabs are yellow

The current studies

Semantic revision

(4) All cabs are yellow

Uttered in Valletta:

The current studies

Semantic revision

(4) All cabs are yellow

Uttered in Valletta: 

The current studies

Semantic revision

(4) All cabs are yellow that are driving around in New York.

The current studies

Semantic revision

(4) All cabs are yellow that are driving around in New York.

Even when uttered in Valletta:

The current studies

Semantic revision

(4) All cabs are yellow that are driving around in New York.

Even when uttered in Valletta: 

1. Background

The current study

- Two ERP studies investigating the incrementality of such semantic restriction processes
- Comparison of different experimental tasks (attended vs. unattended)

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The current studies

General idea

- Comparing pictorial context effects on quantifier restriction in two tasks (picture question verification and probe detection)

- Including well-defined disambiguation positions for observing context effects in the course of the question.

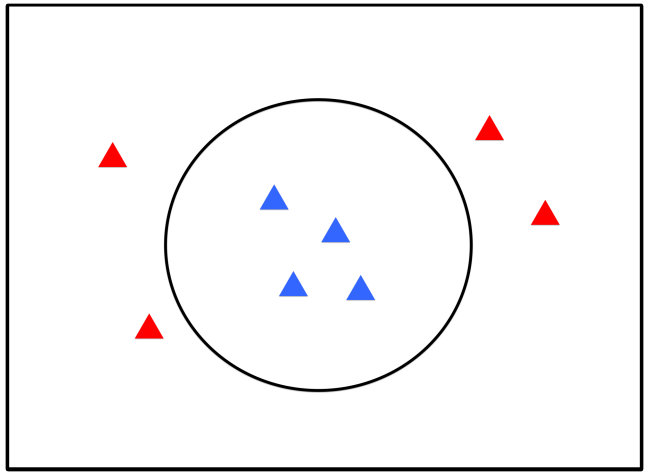
The current studies

Semantic revision

(4) All cabs are yellow that are driving around in New York.

The current studies

General idea, adopted to the present experiments

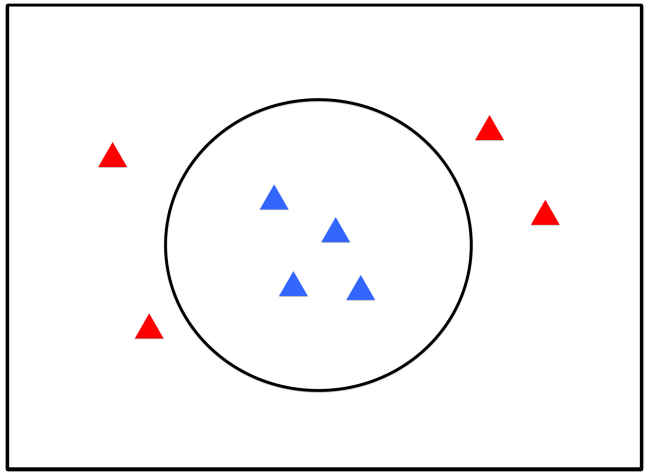


Sind alle Dreiecke blau, die innerhalb des Kreises sind?

Are all triangles blue that are inside-of the circle?

The current studies

General idea, adopted to the present experiments

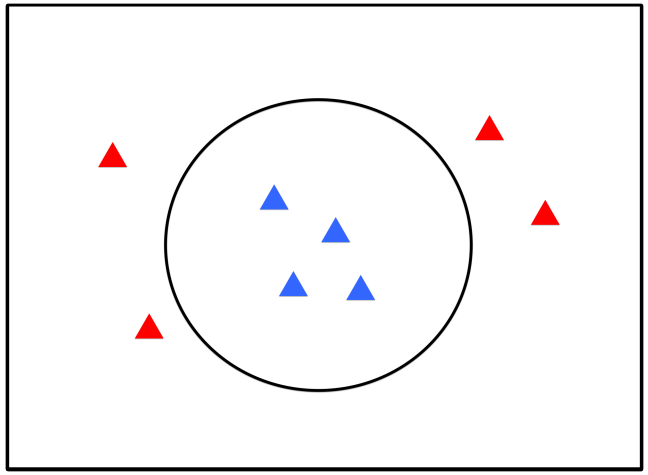


Sind alle Dreiecke **blau**, die innerhalb des Kreises sind?

*Are all triangles **blue** that are inside-of the circle?*

The current studies

General idea, adopted to the present experiments

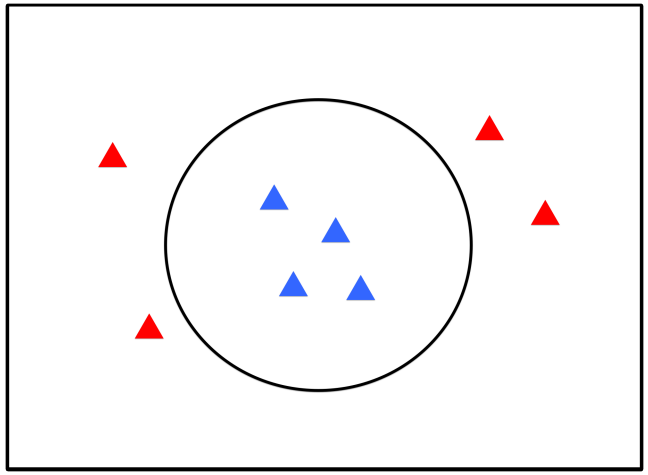


Sind alle Dreiecke blau, die **innerhalb** des Kreises sind?

*Are all triangles blue that are **inside-of** the circle?*

The current studies

General idea, adopted to the present experiments



Sind alle Dreiecke blau, die **innerhalb** des Kreises sind?

*Are all triangles blue that are **inside-of** the circle?*

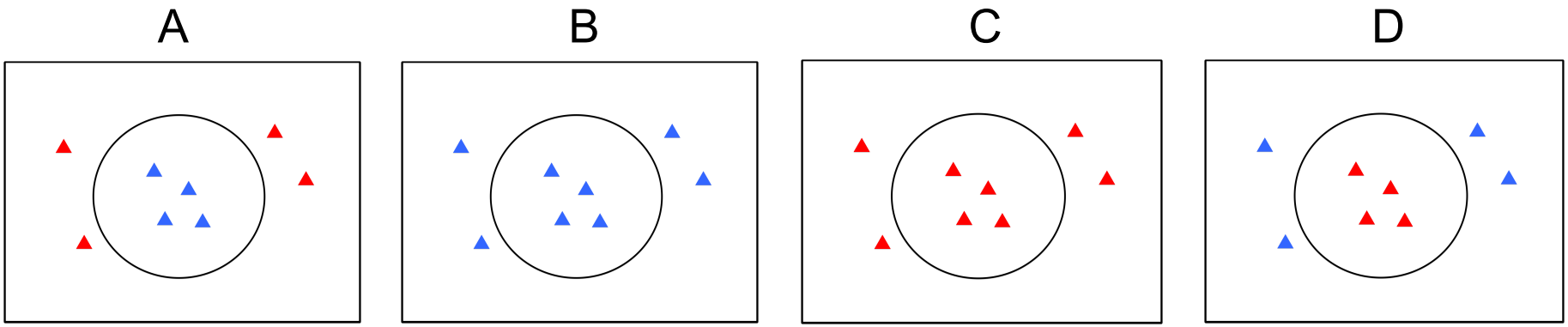
The current studies

General idea

- A local truth evaluation is principally available directly on the colour adjective
- A following restriction can potentially lead to meaning shifts (e.g. from *false* to *true*)

The current studies

Materials



Are all triangles blue that are inside-of the circle?

Are all triangles blue that are outside-of the circle?

→ 160 experimental items plus 160 filler items directly ending on the colour adjective

The current studies

Materials: Simple contexts – no meaning shifts

Are all triangles blue that are ...

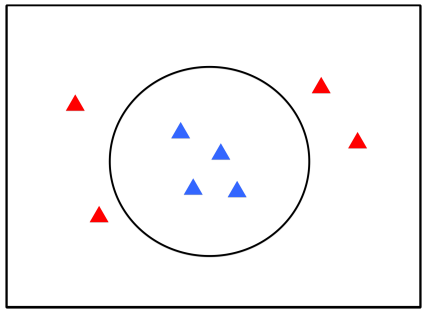
inside-of: *true* → *true*
outside-of: *true* → *true*

inside-of: *false* → *false*
outside-of: *false* → *false*

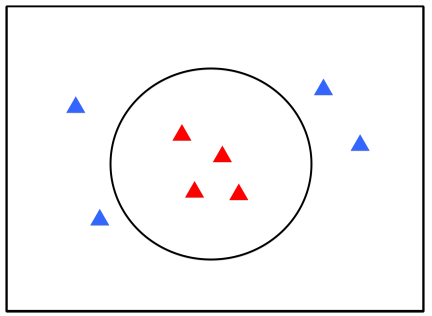
The current studies

Materials: Complex contexts – potential meaning shifts

A



D



Are all triangles blue that are ...

inside-of: *false* → *true*
outside-of: *false* → *false*

inside-of: *false* → *false*
outside-of: *false* → *true*

The current studies

Hypotheses: H1 (Strict incrementality)

- The semantic truth value of a sentence is evaluated as quickly as possible, irrespective of the potential risk of a later semantic revision.
- Local effects already on the colour adjective for all conditions.
- In case of an initially erroneously assigned truth value: semantic revision needed on the preposition.

The current studies

Hypotheses: H2 (Careful incrementality)

- The parser is sensitive toward the risk of a semantic revision.
- An early semantic commitment on the colour adjective is only made when a potentially following restriction will not result in a semantic meaning shift.

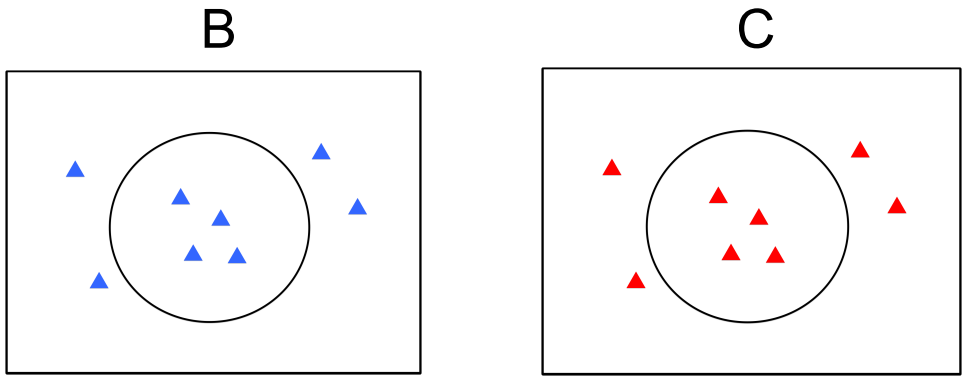
The current studies

Expected components

- **N400** in case of a mismatch between pictorial information and semantic information
- The negativity might be additionally accompanied by a late positivity (see Knoeferle et al., 2011, for discussion)

The current studies

Predictions: simple contexts

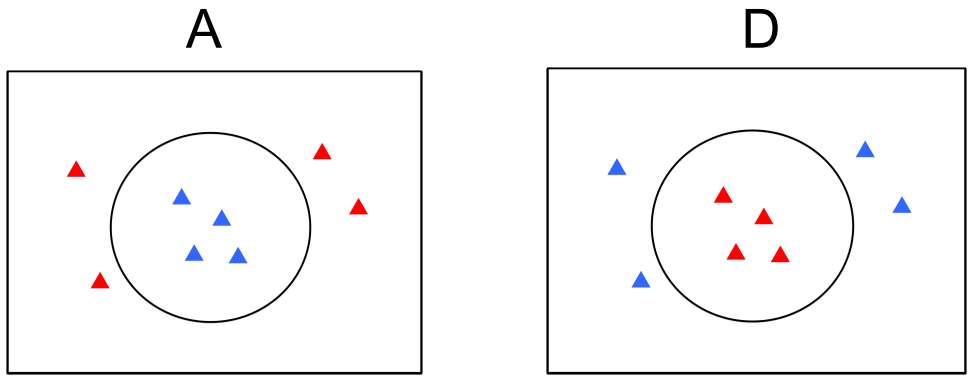


Are all triangles blue that are inside-of/outside-of of the circle?

Both H1 and H2 predict an **N400 for C (*false*) vs. B (*true*)** on the colour adjective. No effects should occur on the preposition.

The current studies

Predictions: complex contexts



Are all triangles blue that are inside-of/outside-of of the circle?

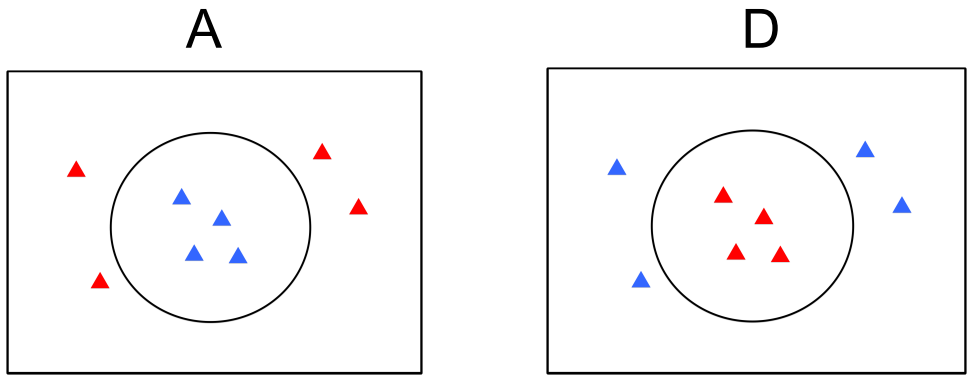
H1:

Colour adjective: N400 (plus pos.), analogous to false contexts

Preposition: **Revision effects**: effect for A *inside-of* vs. *outside-of;* effect for D *outside-of* vs. *inside-of*

The current studies

Predictions: complex contexts



Are all triangles blue that are inside-of/outside-of of the circle?

H2:

Colour adjective: no effects, analogous to true contexts

Preposition: **Mismatch effects**: N400 for A *outside-of* vs. *inside-of;* positivity for D *inside-of* vs. *outside-of*

Experiment 1: Picture question verification

Experiment 1: Picture question verification

Methods:

- Picture-question verification task, in which **attention is focused on the picture-question match**
- 24 German native speakers
- Including electrode preparation, practice session and breaks between blocks: 2-2.5 hrs
- Picture: 1500 ms, then RSVP of the sentence (500 ms / word)

Experiment 1: Picture question verification

Results

1. Colour adjective
2. Preposition (potential reanalysis region)

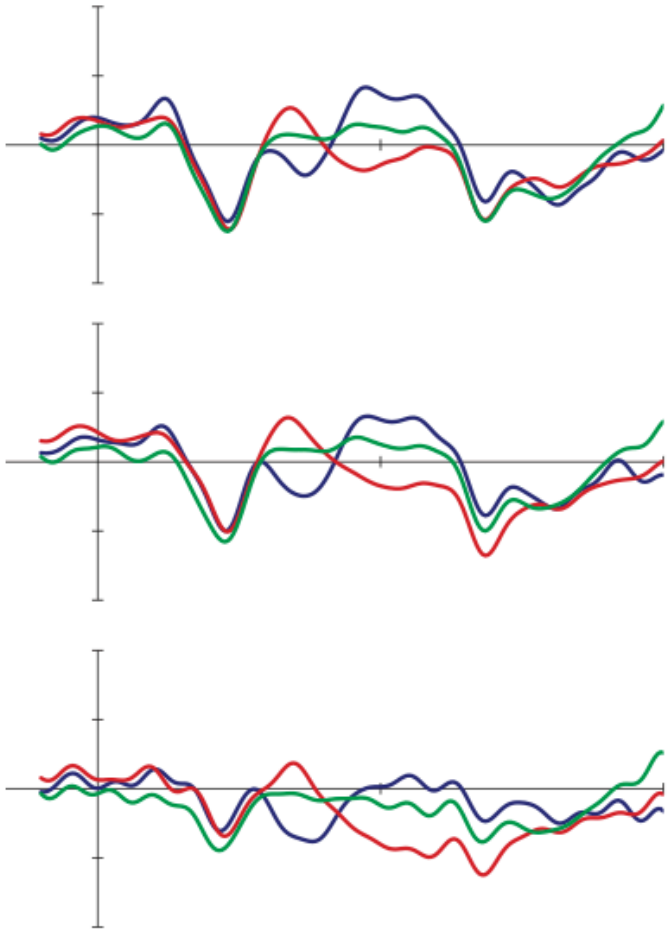
Experiment 1: Picture question verification

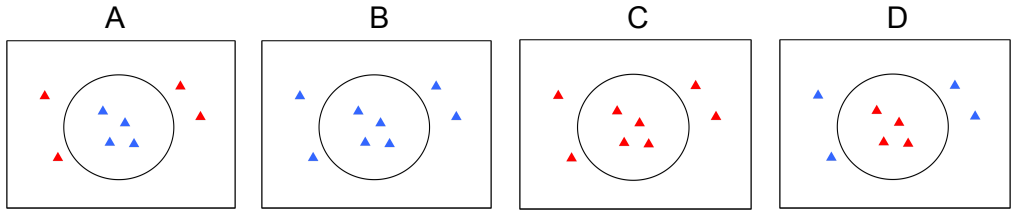
Results

1. **Colour adjective**
2. Preposition (potential reanalysis region)

Experiment 1: Picture question verification

Results: Colour adjective





Are all triangles **blue** ...

B
C
A+D

Experiment 1: Picture question verification

Results: Colour adjective

- In line with H1 and H2: negativity (plus positivity) for the false sentences (C)
- Contrary to H1: no negativity for the complex conditions (A,D)

Experiment 1: Picture question verification

Results

1. Colour adjective
2. Preposition (potential reanalysis region)

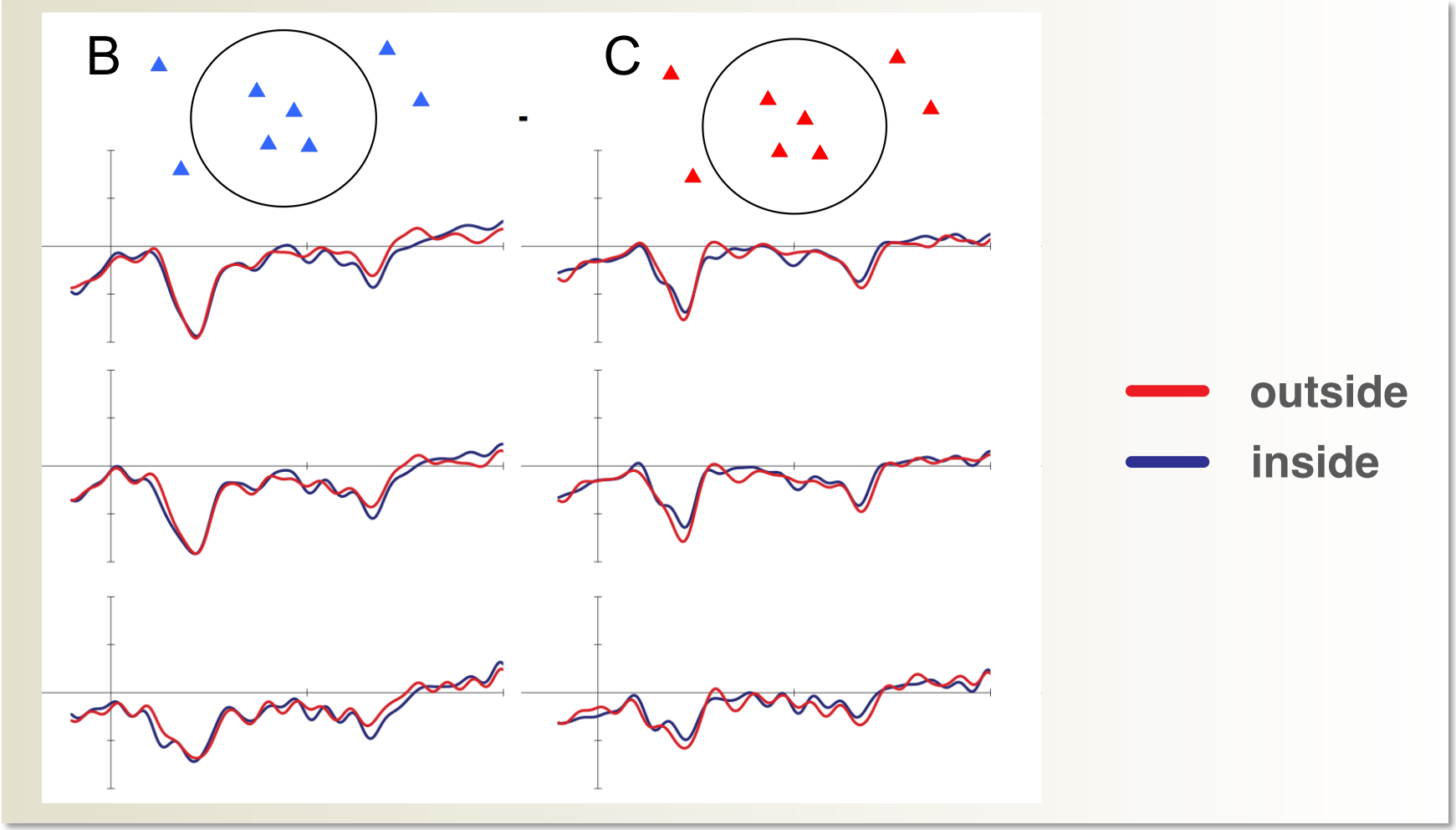
Experiment 1: Picture question verification

Results

1. Colour adjective
2. **Preposition (potential reanalysis region)**

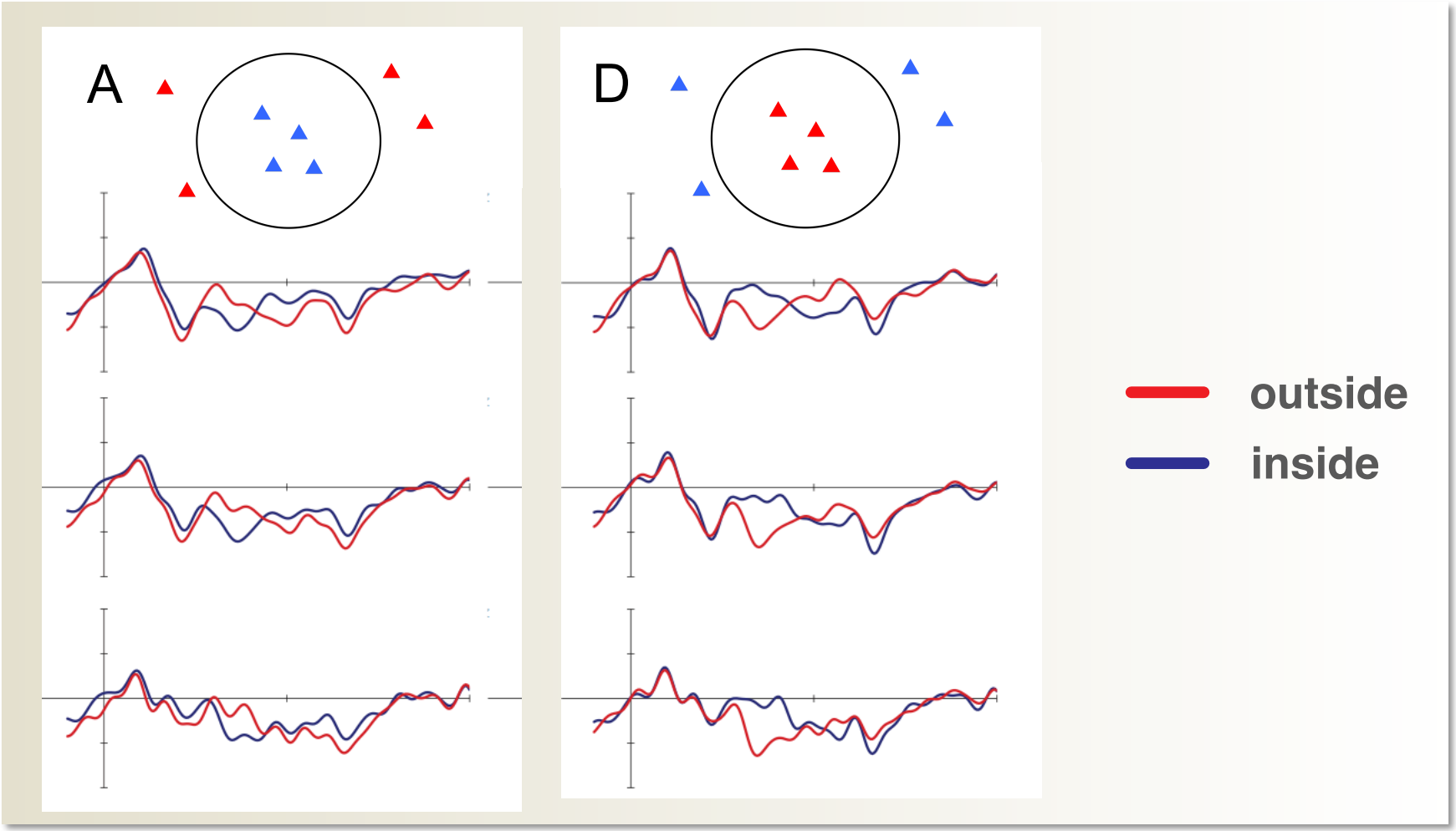
Experiment 1: Picture question verification

Results: Preposition: simple conditions



Experiment 1: Picture question verification

Results: Preposition: complex conditions



Experiment 1: Picture question verification

Results: Preposition

- In line with H1 and H2: no effect for the complex conditions
- Mismatch pattern is in accord with H2 (Careful incrementality)
- Contrary to H1 (Strict incrementality) : the ***directly opposite pattern*** would have been expected under a revision-driven account

Experiment 1: Picture question verification

Discussion

- The present pattern of results is in line with a revision-sensitive version of semantic incrementality.
- In case of a risk of a further restrictive cue, the parser waits until unambiguous information is reached.

Experiment 1: Picture question verification

Discussion

- Both the early negativity and the late positivity had sometimes been associated with strategic effects rather than being language-related.
- Early negativity: N2b component – reflects attentional mismatch detection (Knoeferle et al., 2011; Vissers et al., 2008)
- Late positivity: P3b – reflects increased attentional demands when the currently processed stimulus is relevant for the fulfilment of the task (Sassenhagen et al., 2014)

Experiment 1: Picture question verification

Discussion

- Experiment 2 will thus use a different experimental paradigm that is intended to shift attention away from the picture-question match

Experiment 2: Probe detection

Experiment 2: Probe detection

General idea

- Directing attention away from the mapping between context and the question.
- In principle, the probe detection task could be realized without relating the picture to the question at all.

  → occassionally (15% of all trials: participants should answer the question)

Experiment 2: Probe detection

Materials

- Identical experimental items as in Experiment 1
- Probe Positions:

Sind alle **Dreiecke blau**, die **innerhalb** des **Kreises** sind?

Picture # Form 1 # Adjective # Preposition # Form 2

Experiment 2: Probe detection

Methods:

- Probe detection task (**attention is guided away** from the picture-question mismatch)
- 22 German native speakers
- Including electrode preparation, practice session and breaks between blocks: 2-2.5 hrs
- Picture: 1500 ms, then RSVP of the sentence (500 ms / word)

Experiment 2: Probe detection

Results

1. Colour adjective
2. Preposition (potential reanalysis region)

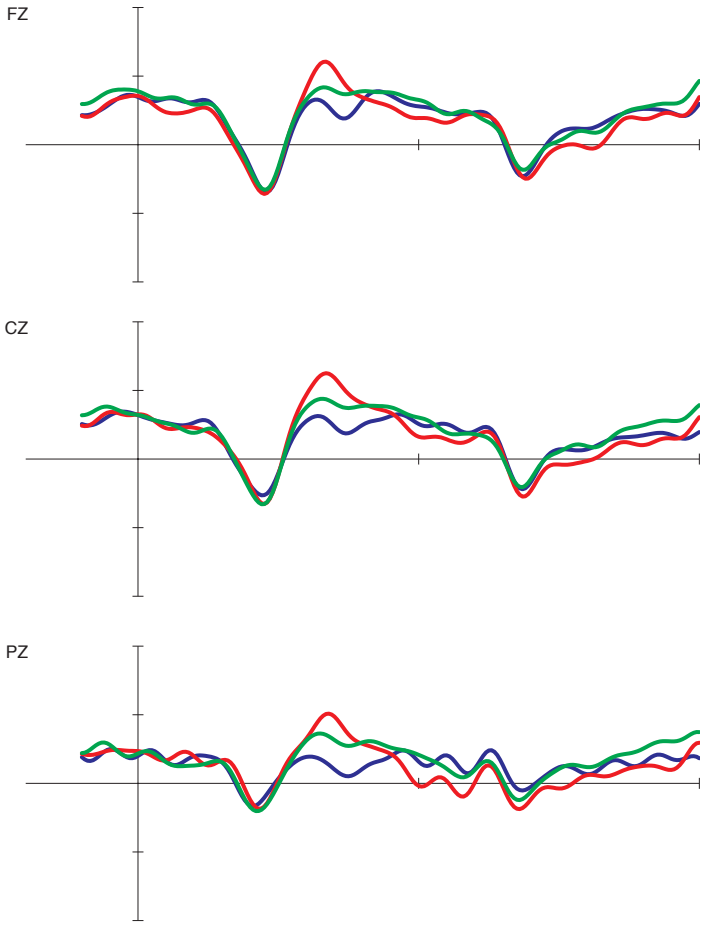
Experiment 2: Probe detection

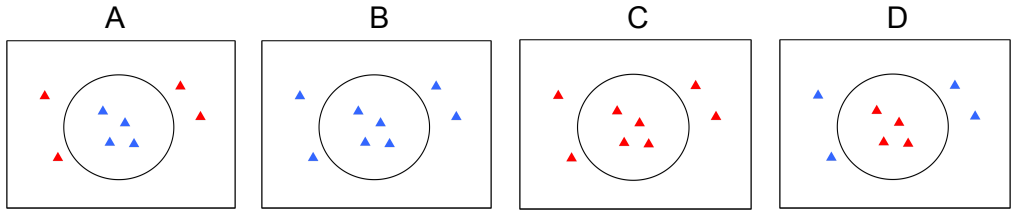
Results

1. **Colour adjective**
2. Preposition (potential reanalysis region)

Experiment 2: Probe detection

Results: Colour adjective





Are all triangles **blue** ...

B

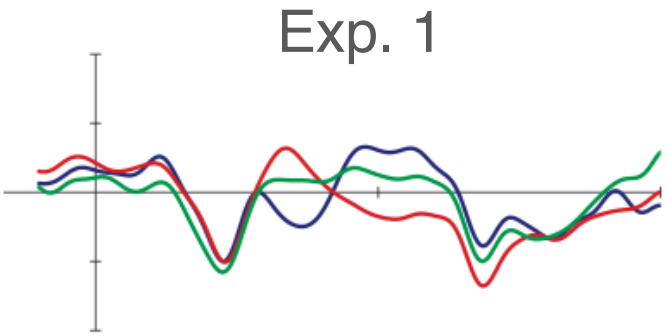
C

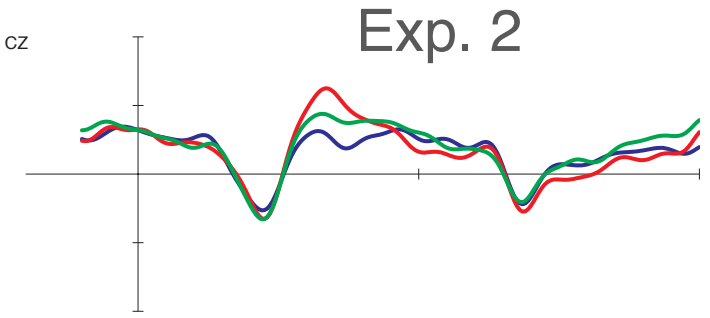
A+D

Experiment 2: Probe detection

Results: Colour adjective

- No late positivity!





Experiment 2: Probe detection

Results

1. Colour adjective
2. Preposition (potential reanalysis region)

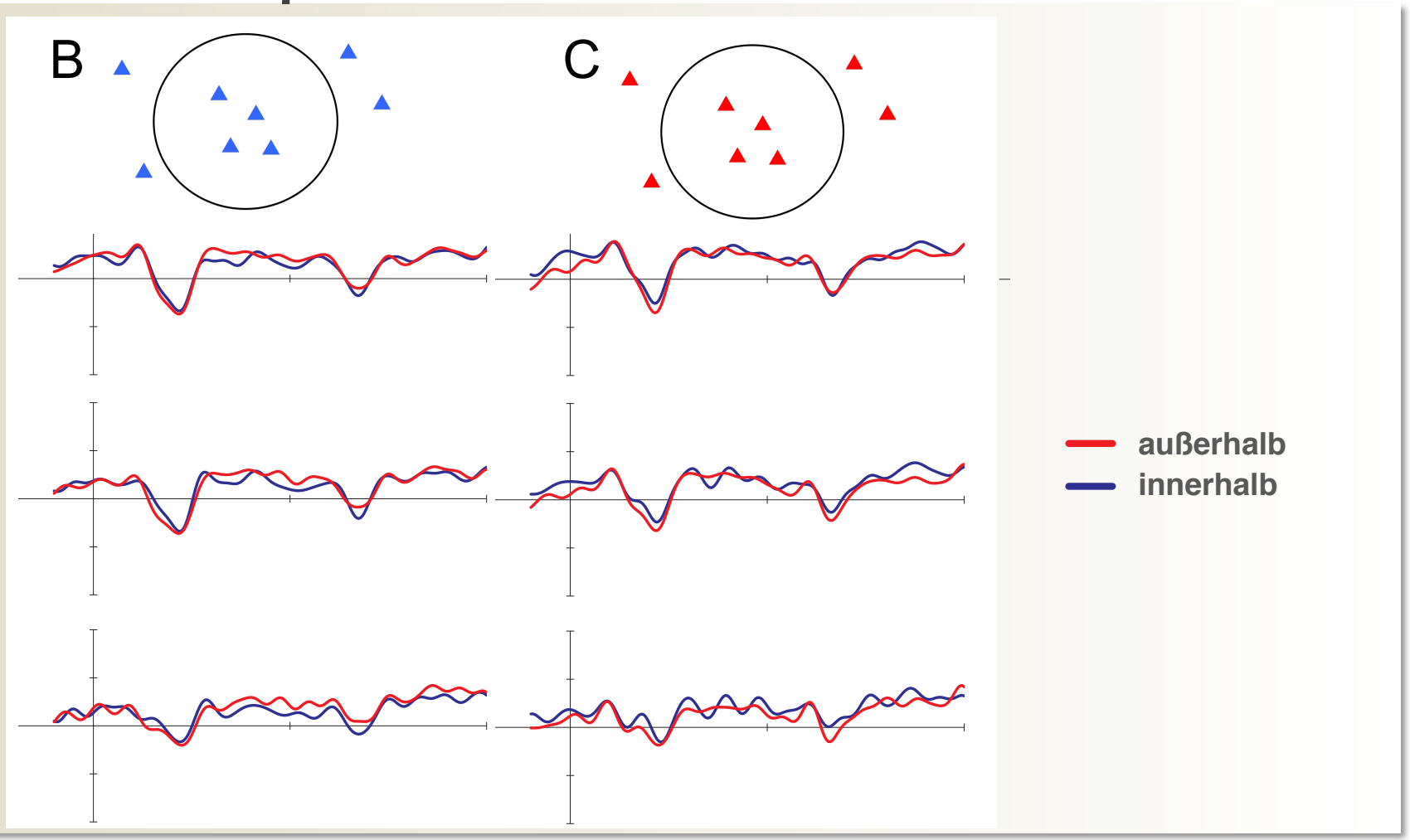
Experiment 2: Probe detection

Results

1. Colour adjective
2. **Preposition (potential reanalysis region)**

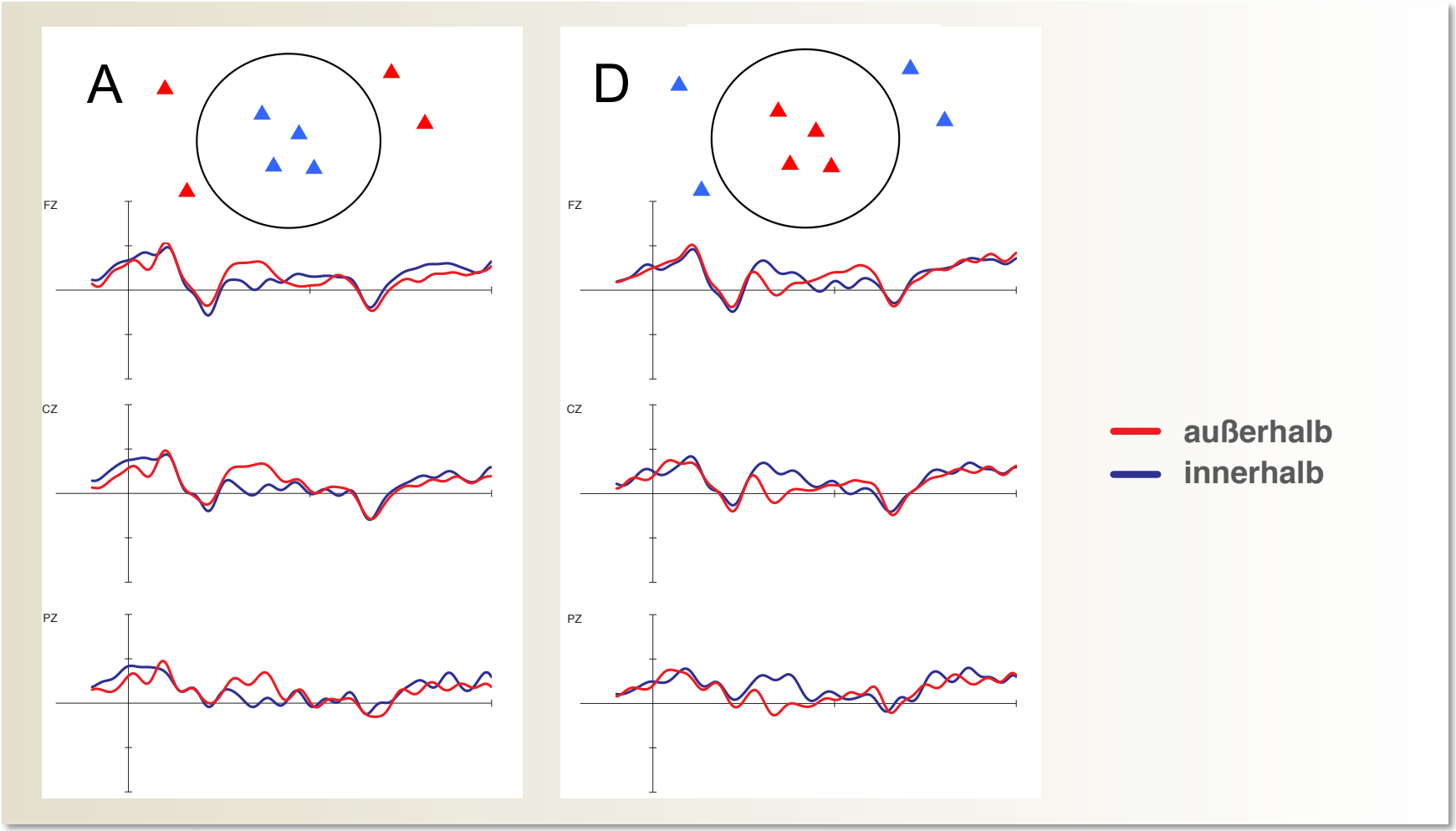
Experiment 2: Probe detection

Results: Preposition



Experiment 2: Probe detection

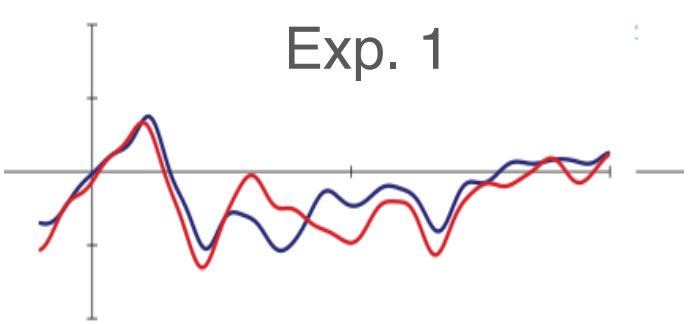
Results: Preposition

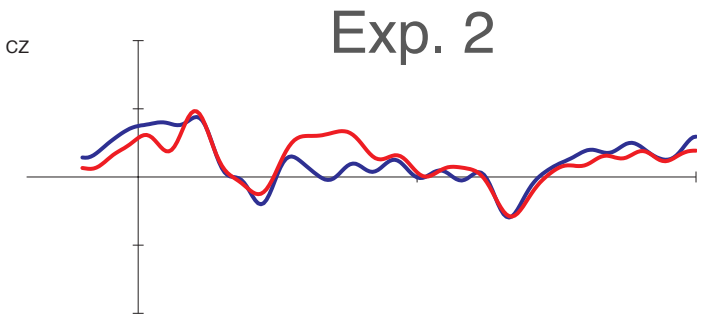


Experiment 2: Probe detection

Results: Preposition

- no late positivity!





Experiment 2: Probe detection

Discussion

- Analogous to Experiment 1: Evidence for Careful incrementality (H2)
- The presence of the early negativity is independent of the attention manipulation
- Late positivity: absent under the present task: seems to have been elicited by attentional focus towards the picture-question mapping

Experiment 2: Probe detection

Discussion: the early negativity

- could be an instance of the N2b component
- under such a view, the component reflects a representational mapping between the picture and the lexical properties of the actually encountered word
- alternatively: N400 associated with answering the question – increased processing demands due to the presence of an additional negation step (see also Hunt III et al, for a similar pattern for false vs. true sentences)

Experiment 2: Probe detection

Discussion: positivity

- could be seen as a member of the P3 family
- increased attentional demands when the processed stimulus is highly important for the fulfilment of the task
- often related to binary decisions (Sassenhagen et all., 2014)

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3. Summary

Questions

- Does non-linguistic information incrementally constrain compositional-semantic interpretation?
- Is there evidence for semantic reanalysis effects during online sentence comprehension?
- What are the neurophysiological correlates of compositional-semantic processing difficulties?

3. Summary

Questions

- Does non-linguistic information incrementally constrain compositional-semantic interpretation?

  In the current studies it does, but only if contextual information is unambiguous and does not come with the risk of a semantic revision process.

3. Summary

Questions

- Does non-linguistic information incrementally constrain compositional-semantic interpretation?
- Is there evidence for semantic reanalysis effects during online sentence comprehension?
- What are the neurophysiological correlates of compositional-semantic processing difficulties?

3. Summary

Questions

- Does non-linguistic information incrementally constrain compositional-semantic interpretation?
- Is there evidence for semantic reanalysis effects during online sentence comprehension?

No. But this might be different when considering other constructions.

3. Summary

Questions

- Does non-linguistic information incrementally constrain compositional-semantic interpretation?
- Is there evidence for semantic reanalysis effects during online sentence comprehension?
- What are the neurophysiological correlates of compositional-semantic processing difficulties?

3. Summary

Questions

- Does non-linguistic information incrementally constrain compositional-semantic interpretation?
- Is there evidence for semantic reanalysis effects during online sentence comprehension?
- What are the neurophysiological correlates of compositional-semantic processing difficulties?

  In the present experiments, these were reliably reflected by a negative-going deflection.

Thank you for your attention!

3. Folgestudien

Vergleich semantische und pragmatische Verarbeitung

- *some* statt *all*
- Unterschiedliche Monotonie-Eigenschaften der Quantoren
- Gegensätzliche Wahrheitswertbedingungen
- Zusätzlicher pragmatischer Prozess

2. EEG-Studie 1: Picture Question Verification

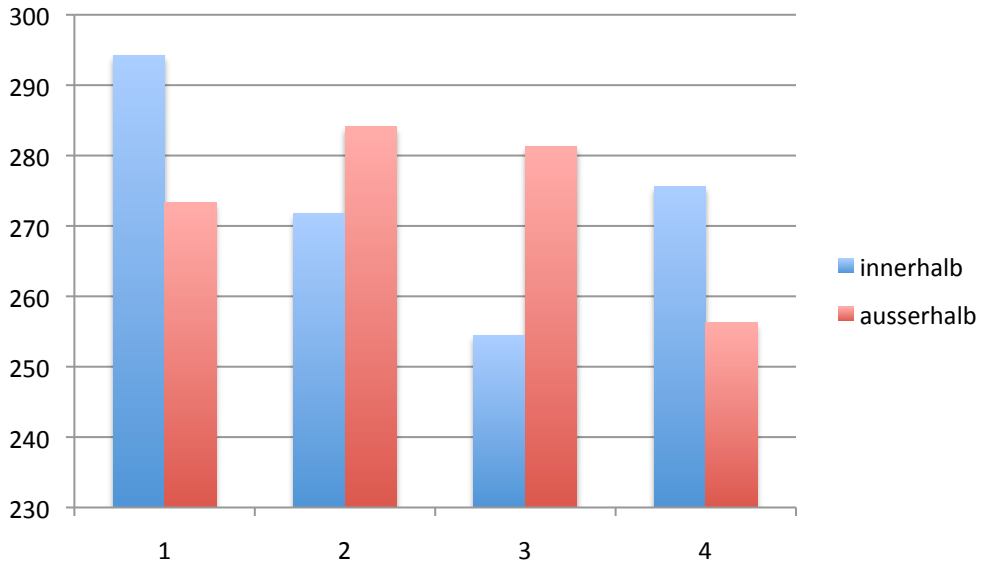
Behaviorale Ergebnisse

Table 3. Behavioral results for the single conditions in Experiment 1.

	Verification results	
Condition	**Correct responses (%)**	**Reaction times (ms)**
A *innerhalb*	96.1	294.2
A *außerhalb*	98.6	273.4
B *innerhalb*	99.0	271.7
B *außerhalb*	91.3	284.1
C *innerhalb*	96.5	254.5
C *außerhalb*	98.4	281.3
D *innerhalb*	99.2	275.6
D *außerhalb*	90.1	256.3

2. EEG-Studie 1: Picture Question Verification

Behaviorale Ergebnisse



→ behaviorale Daten eigentlich nicht interpretierbar (häufig RT < 10 ms)

2. EEG-Studie 2: Probe Detection

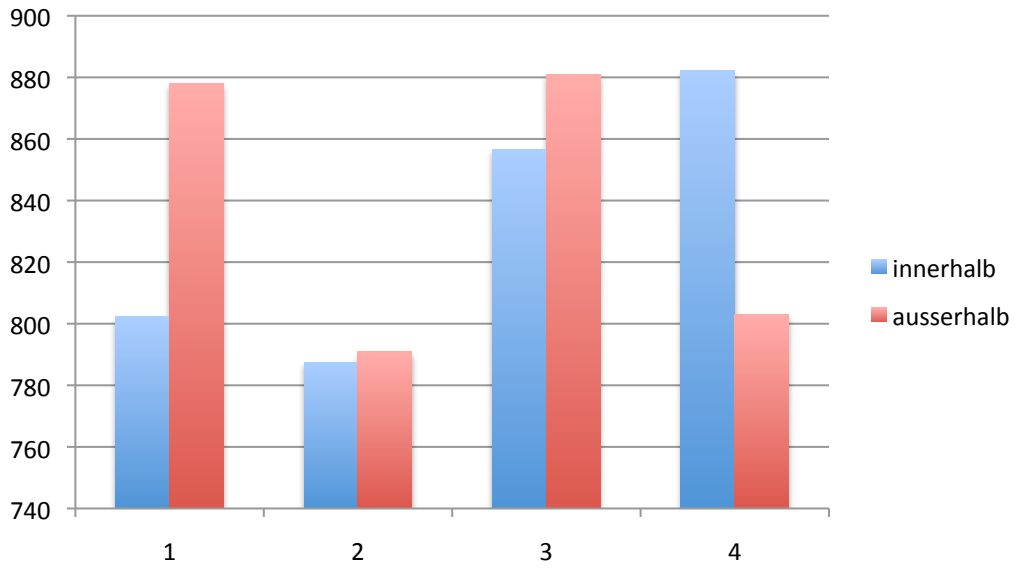
Behaviorale Ergebnisse

Table 5. Behavioral results for the single conditions in Experiment 2

	Probe detection results	
Condition	**Correct responses (%)**	**Reaction times (ms)**
A *innerhalb*	79.8	802.2
A *außerhalb*	71.3	878.1
B *innerhalb*	77.6	787.6
B *außerhalb*	83.0	790.9
C *innerhalb*	80.5	856.7
C *außerhalb*	73.9	880.9
D *innerhalb*	74.8	882.2
D *außerhalb*	81.5	803.1

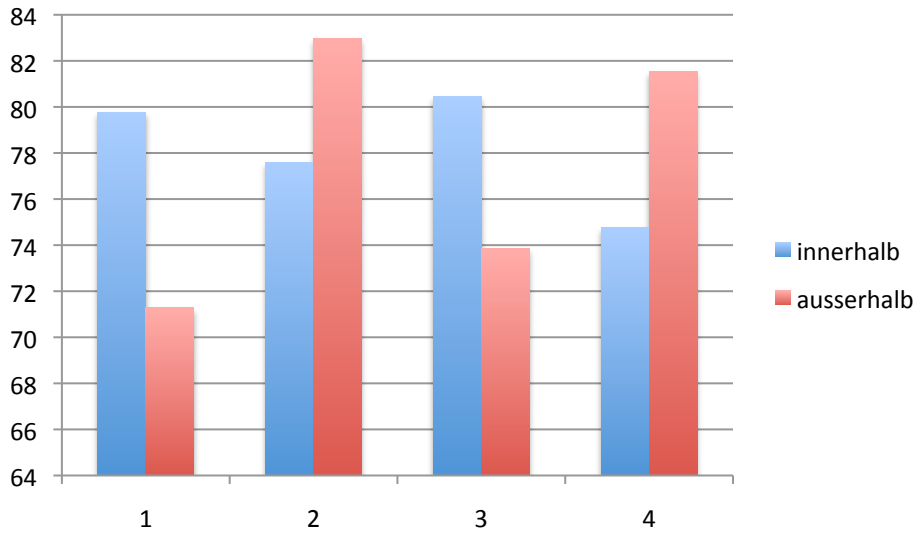
2. EEG-Studie 2: Probe Detection

Behaviorale Ergebnisse



2. EEG-Studie 2: Probe Detection

Behaviorale Ergebnisse



Experiment 1: Picture question verification

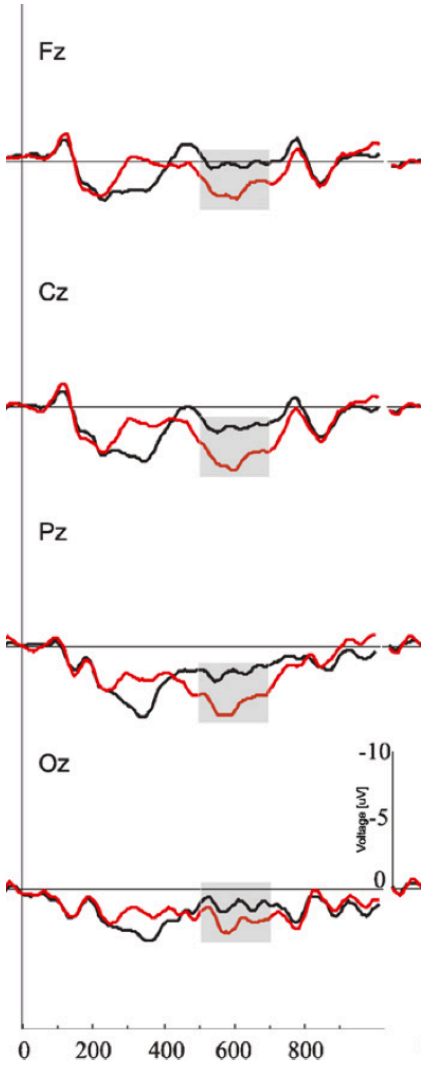
Discussion

- e.g. Vissers et al., 2008 (see also D'Arcy & Connolly, 1999)

☐ △ De driehoek staat achter het vierkant
The triangle stands behind the square

☐ △ De driehoek staat voor het vierkant
The triangle stands in front of the square

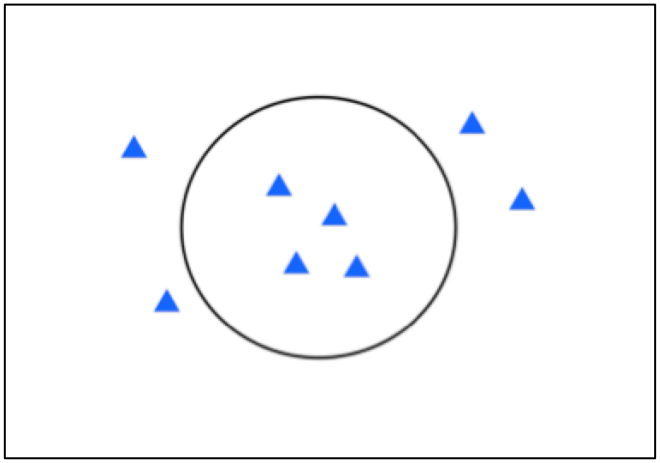
☐ △ De driehoek staat boven het vierkant
The triangle stands above the square

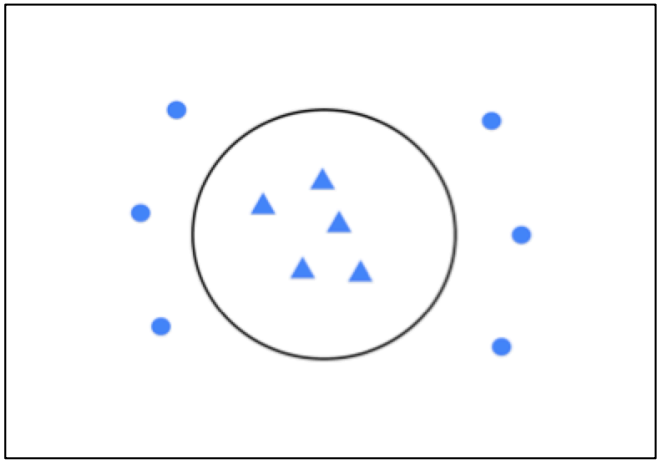


Experiment 2: Probe detection

Materials

- Example for a visual probe (mismatch)





1. Background

Quantifier restriction

- At present: relatively **few neurophysiological studies** on the temporal dynamics of contextual effects on sentences containing quantifiers